CATION

SCHOOL OF EDUCATION
LIBRARY

JUL 28 1950

The Journal of Experimental Education

A periodical report of scientific investigations relating to child development, curriculum, learning, teaching, supervision, measurements, statistics, and experimental techniques.

Volume XVIII | June, 1950 | Number 4

CONTENTS *Page*

Factor Analyses of Prospective Teachers' Differences:
John Schmid, Jr. 287

A Study of Laterality Characteristics of Retarded Readers and Reading Achievers:
Linda C. Smith 321

Substance Symbolism: A Study in Language Psychology:
Gustav Kaldegg 331

Effect of the Organization of Learning Experiences Upon the Organization of Learning Outcomes: II. Study of the Problem by Means of Factor Analysis:
Edward J. Furst 343

$5.00 A YEAR | PUBLISHED QUARTERLY | $1.50 A COPY

Published by Dunbar Publications, Inc., 114 S. Carroll Street, Madison 3, Wisconsin.
Entered as second-class matter October 17, 1932 at the post office at Madison, Wisconsin under the act of March 3, 1879.

EDITORIAL BOARD

A. S. Barr, Chairman, Professor of Education, University of Wisconsin, Madison 6, Wis.

Arthur T. Jersild, Professor of Education, Teachers College, Columbia University, New York City. Editorially responsible for materials on child welfare, guidance, and development, published each December.

Palmer O. Johnson, Professor of Education, University of Minnesota, Minneapolis, Minnesota. Editorially responsible for materials on measurements, statistics, and methods of experimental research, published each March.

H. H. Remmers, Professor of Educational Psychology, Director Division Educational Reference, Purdue University, Lafayette, Indiana. Editorially responsible for materials on learning, teaching and supervision, published each September.

J. Wayne Wrightstone, Director, Bureau of Educational Research, Board of Education of the City of New York, Brooklyn, New York, 110 Livingston Street, Brooklyn, New York. Editorially responsible for materials on curriculum construction, published each June.

CONTRIBUTING EDITORS

Emmett A. Betts, Research Professor and Director of Reading Clinic, Pennsylvania State College, State College, Pennsylvania.

Gilbert L. Betts, Supervisor of Graduate Research in Education, Colorado State College, Fort Collins, Colorado.

Leo J. Brueckner, Professor of Education, University of Minnesota, Minneapolis, Minnesota.

Oscar K. Buros, Associate Professor of Education, Rutgers University, New Brunswick, New Jersey.

Guy T. Buswell, Professor of Educational Psychology, University of Chicago, Chicago, Illinois.

Harold D. Carter, Associate Professor of Education, University of California, Berkeley 4, California.

Leslie L. Chisholm, Associate Professor of Education, State College of Washington, Pullman, Washington.

Herbert S. Conrad, Technical Consultant, College Entrance Examination Board, Princeton, New Jersey.

Stephen M. Corey, Professor of Educational Psychology, University of Chicago, Chicago, Illinois.

Edward E. Cureton, 853 East Brewster Road, Alcoa, Tennessee.

Robert A. Davis, Professor of Education, Director of Bureau of Educational Research, University of Colorado, Boulder, Colorado.

Harl R. Douglass, Director of College of Education, University of Colorado, Boulder, Colorado.

Harold A. Edgerton, Director, Occupational Opportunities Service, Professor of Psychology, Ohio State University, Columbus 10, Ohio.

John C. Flanagan, Professor of Psychology, University of Pittsburgh, Pittsburgh, Pennsylvania.

Carter V. Good, Dean, Teachers College, University of Cincinnati, Cincinnati 21, Ohio.

Robert W. B. Jackson, Assistant Professor of Educational Research; Assistant Director, Department of Educational Research, Ontario College of Education, University of Toronto, Toronto, Canada.

Harold E. Jones, Professor of Psychology and Director, Institute of Child Welfare, University of California, Berkeley 4, California.

Noel Keys, Professor of Education and Lecturer in Human Relations, University of California, Berkeley, California.

D. Welty Lefever, Professor of Education, University of Southern California, Los Angeles, California.

Edward A. Lincoln, Consulting Psychologist, Halifax, Massachusetts.

Irving Lorge, Professor of Education, Executive Officer, Institute of Psychological Research, Teachers College, Columbia University, New York 27, New York.

A. R. Mead, Director of Educational Research, University of Florida, 330 P. K. Yonge Building, Gainesville, Florida.

T. E. Newland, Lt. Comdr., USNR, 2702 Wisconsin Avenue, N. W., Washington 7, D. C.

C. W. Odell, Professor of Education, University of Illinois, Urbana, Illinois.

Willard C. Olson, Professor of Education, Director of Research in Child Development, University of Michigan, Ann Arbor, Michigan.

V. E. Peik, Dean and Professor of Education, University of Minnesota, Minneapolis, Minnesota.

Valworth R. Plumb, Chairman, Division of Education and Psychology, University of Minnesota (Branch), Duluth, Minnesota.

S. L. Pressey, Professor of Educational Psychology, Ohio State University, Columbus, Ohio.

Clarence E. Ragsdale, Professor of Education, University of Wisconsin, Madison, Wisconsin.

William Reitz, Associate Professor of Education, College of Education Examiner, Wayne University, Detroit 2, Michigan.

Henry D. Rinsland, Professor of Education and Director of Educational Research, The University of Oklahoma, Norman, Oklahoma.

Robert T. Rock, Jr., Professor of Psychology, Head of Dept. of Psychology, Graduate School, Fordham University, New York City.

Phillip J. Rulon, Professor of Education, Harvard Graduate School of Education, Cambridge 38, Massachusetts.

Douglas E. Scates, Professor of Education, Duke University, Durham, North Carolina.

John Schmid, Board of Examiners, Michigan State College, East Lansing, Michigan.

Harold Seashore, Director, Test Division, The Psychological Corporation, New York 18, New York.

David Segel, Educational Consultant, Specialist in Tests and Measurements, Federal Security Agency, U. S. Office of Education, Washington, D. C.

Paul W. Terry, Professor of Educational Psychology, University of Alabama, University, Alabama.

Helen Thompson, Associate Attending Psychologist, New York Post-Graduate Hospital, 303 East 20th Street New York 3, N.Y.

Robert L. Thorndike, Associate Professor of Education, Teachers College, Columbia University, New York City.

Herbert A. Toops, Professor of Psychology, Ohio State University, Columbus, Ohio.

Maurice E. Troyer, Director, Bureau of School Services, Syracuse University, Syracuse 10, New York.

Helen M. Walker, Professor of Education, Teachers College, Columbia University, New York City.

Beth L. Wellman, Professor of Psychology, Child Welfare Research Station, State University of Iowa, Iowa City, Iowa.

Guy M. Wilson, Emeritus Professor of Education Boston University, 33 Pine Street, Wellesley Hills, Massachusetts.

Paul A. Witty, Professor of Education, Director of Psycho-Educational Clinic, School of Education, Northwestern University, Evanston, Illinois.

Ernest R. Wood, Professor of Education, New York University, New York City.

D. A. Worcester, Chairman Department of Educational Psychology and Measurement, University of Nebraska, Lincoln, Nebraska.

LITHOGRAPHED BY LITHO PRODUCTIONS - MADISON, WISCONSIN

Jo

Vo

Stater

A
are u
the p
and a
many
they
measu
conom
educa
the ar
numb
Th
pothe
ment
ure o
resta
comm
also,
"T
tions,
means
edge,
Sp
be an
1.
ventor
subte
nesot
ure s
2.
measu
pretat
3.
such
ages,
ard te
4.
dents

*The w
their

Journal of Experimental Education

Volume XVIII June, 1950 Number 4

FACTOR ANALYSES OF PROSPECTIVE TEACHERS' DIFFERENCES

JOHN SCHMID, Jr.*
Michigan State College
East Lansing, Michigan

SECTION I

INTRODUCTION

Statement of the Problem

A large number of data-gathering devices are used, currently, in obtaining measures of the personality, achievement, personal history, and abilities of prospective teachers. Perhaps many of the obtained measures overlap in that they measure essentially the same traits. If measures overlap in part or entirely, it is economic from the standpoint of administration, educational policy, and research to determine the areas of overlap and accordingly reduce the number of measuring instruments.

The purpose of this study was to test the hypothesis: Tests currently used in the measurement and prediction of teaching efficiency measure only a few traits of prospective teachers; or restated, each test measures personal aspects common to other tests concomitantly used and, also, measures something peculiar to itself.

"Test" is defined as any of the set of questions, rating scales, checklists, and similar means for measuring a student's skills, knowledge, or special capacities.

Specifically, the following questions were to be answered:

1. Do the Washburne Social Adjustment Inventory, Mooney Problem Check List, and their subtest sections, and certain scales of the Minnesota Multiphasic Personality Inventory measure similar personality dimensions?
2. If a few common factors underlie these measures of personality, can meaningful interpretation be made of these factors?
3. Do these factors underlie other measures such as total and professional grade point averages, professional judgment, and attitude toward teaching?
4. Do male students differ from female students in factor pattern?
5. Is a Yes-response set indicative or factorially related to the practice teaching grade?

Importance of the Problem

With the changing sociological frontier, there is the realization that education is not merely an implement for transmitting cultural values from one generation to the next, but that education, with other institutions of society, performs its functions best by periodic redefinitions of its values. Consequently, the teacher as an important agent in these processes has come under the close scrutiny of the philosopher and the scientist. The teacher is no longer regarded just as the director of the learning process, but as the guide to growing children and the friend and counselor of pupils, As a member of a group of professional workers, he is expected to have qualities that are conducive to group work. He also has his responsibilities as a neighbor and citizen in the community.

This broadened concept of the teacher's role in society poses problems of prediction, selection, and the education of a new order. Teacher education institutions have attempted to gain a many-sided picture of their candidates by using a variety of measures. Grades, personality inventories, intelligence tests, and autobiographies serve as typical sources of information about the prospective teacher. The investigation, simplification, and systemization of these many measured aspects and qualities becomes imperative. If it can be demonstrated that personal data are measuring a few fundamental traits, problems in the general and professional education of teachers will be reduced.

An immediate benefit derived from the reduction of measures would be in the direction of a standardized vocabulary. The need for an exact and uniform vocabulary in education cannot be overestimated. At present, a jungle of terminology confronts the educationist and obscures not only the purposes and aims of education but

*The writer wishes to express his appreciation to Dr. A. S. Barr and Dr. C. W. Harris for their guidance and generous assistance in carrying out this study.

also the application of scientific thinking to education. It may be expected that as measuring instruments are refined, inconsistencies of educational terminology will be mitigated.

Reduction of measures has other benefits. Not only may computational labor and time be saved in the prediction of good teachers, but the accuracy of prediction may be improved. It may be demonstrated analytically and experimentally that accuracy of prediction does not improve with the inclusion of an increasing number of variables in a regression equation, but rather, accuracy is lost beyond a certain limit. Guttman (16:298-300) has shown that the stability of regression coefficients is dependent upon the ratio of the number of the predicting variables to the number of cases in the original sample used to develop the regression coefficients.

Reduction should not be construed to mean elimination of pertinent information or data, but rather, the identification of those components which, entering into many measures, are not easily discernible. Factor analysis may be considered as a means of summarizing a large number of measures in terms of a few hypothetical measures.

Plan of the Study

In order to carry out the analyses, numerical descriptions of the traits defined by the behavior responses of students to various tests were tabulated. The tests scores of samples of female and male students served as the numerical descriptions of the traits. These scores were intercorrelated for the female and male groups separately. The correlation matrices were factored, and the derived parameters were taken as defining the common factors. Inferences about the natures of these factors were made on the bases of the magnitudes of the coefficients defining the factors.

SECTION II

THEORETICAL ASPECTS OF EDUCATIONAL MEASUREMENT AND FACTOR ANALYSIS

Educational and Psychological Measurement

In order to establish the relationship between personal traits and the mathematical logic of factor analysis, certain aspects of measurement must be examined. The question arises: "On what grounds may a set of scores obtained relative to a sample of students be taken as a numerical description of a specified trait?" Descriptive numbers are an implement for ordering phenomena. Somewhere the genesis of these numbers occurred through what might be called common sense of competent people. In educational and psychological measurement, these people are men who through experience and study have shown themselves to be competent in these areas.

In order that a relationship may be established between a trait and set of numbers, the dictum "if a thing exists, ... it can be measured" may be read in converse: "If a thing can be measured, it exists." The first postulation made by competent authorities is that the specified trait exists to varying degrees in individuals. If a sensible test can be constructed, and if that test educes individual differences in specified behavior responses as revealed by varying numerical scores, a one to one correspondence between the scores and varying degrees of the trait is inferred, and the hypothesis of the existence of the trait in varying amounts is accepted. The crux of psychological measurement lies here. The correspondence between the scores and the specified trait, rather than between the scores and some spurious trait, is taken as a valid relationship on the basis that the test was sensibly designed to measure the trait under investigation. The numerical scores by virtue of ordering the individuals serve as a description not only of the individuals, but also the trait. Such scores do not indicate how much of the trait is possessed by individuals, but only how the individuals are ordered. Increasing consecutive scores do not necessarily represent equally increasing amounts of the trait, and therefore, the ordinary rules of algebra are not truly applicable to these numbers. Educational and psychological measurement has not attained that level of sophistication wherein a set of scores possesses the property of cardinality that is prerequisite for the application of algebraic and arithmetic logic. Nevertheless, numerical scores have been treated as cardinal numbers with some success. Thurstone (26:368-9) has demonstrated empirically that this deficiency does not prohibit the use of factorial methods in education and psychology when certain conditions are fulfilled.

Because a varying set of numerical scores imply the existence of a trait to varying degrees in a group of individuals, the trait or the corresponding set of scores frequently is referred to as a variable. Hereafter, these terms will be used interchangeably.

The property of variability in a set of scores may also be expressed by a single number called "variance." Variance may be calculated by finding the average squared differences between the scores and their mean. As will be seen later, qualifications about the variances of traits determine the choice of the factorial methods to be used in a particular study.

Correlation

Suppose two different tests have been designed to measure the same trait. If the two

tests are valid, it may be expected that they will rank individuals similarly: that is, an individual who receives a high score on one test will receive a high score on the other test. An analogous process in physical measurement may be performed by using one ruler graduated in inches and another ruler graduated in centimeters to co-rank lengths of table tops. If the tests measure different traits, it is not to be expected that agreement in the two sets of scores will occur, any more than would agreement be expected, let us say, between lengths and prices of men's shoes. Conversely, if two sets of scores resemble each other perfectly, the inference may be made that the traits being measured or causal factors underlying these traits are the same. If the resemblance of the two sets of scores is less than perfect, the inference may be made that other causal factors not common to both are operating to disturb the perfect agreement.

The degree of resemblance between two sets of scores, and consequently the degree of concomitant variation, is described numerically by a coefficient of correlation. Two types of coefficients have been designed to indicate the degree of correlation: the phi-coefficient and the Pearson product-moment coefficient. To meet a variety of assumptions underlying experimentally derived data, estimates of the Pearson coefficient have been formulated. Some of these estimates are the tetrachoric r, bi-serial r, and the rank correlation coefficient. In the remainder of this exposition, coefficient will mean the Pearson product-moment coefficient of correlation. It is calculated by finding the average product of paired scores expressed in standard units.

It may be seen that because a coefficient numerically describes the agreement between two sets of scores, it may also be taken as indicative of the presence or absence of a common trait or common causal factor.

If the intercorrelations of several variables are significantly different from zero, the presence of a common factor is suggested in all variables. Fortunately, factor analysis predicted upon matrix algebra makes possible the investigation of many correlations simultaneously. Any table of numbers may be thought of as a matrix. Tables of numbers may be operated upon; that is, added, subtracted, multiplied, and divided, according to mathematical rules very much in the same manner as simple numbers. In the following discussion, the reader's knowledge of matrix algebra will be presumed.

Factor Analysis

The rationale underlying factor analysis may be illustrated with an analogy involving arithmetic numbers. If the number 5.93 has been obtained through measurement, it may be considered as factorable into 2.3 on the assumption that, as an approximate number, 5.93 is not significantly different from 6.

In factor analysis, the variables are intercorrelated to produce a matrix R of correlations. If correlations, significant in proportion to their standard error, appear in clusters in the matrix, common factors are inferred. The object in factor analysis is to derive from R mathematically two matrices which multiplied together will reproduce the correlations within sampling error. These factor matrices must be "simpler" than the test score matrix which produced R, in that, the arrays representing the factors must be fewer than the number of tests. The two factor matrices need not be similar unless the common factors are orthogonal or uncorrelated.

In order to show how R may be constructed by means other than intercorrelating the variables, postulate any of the test variables as having the linear composition

$$(1) \quad Z_j = a_{j_1}F_1 + a_{j_2}F_2 + \ldots\ldots + a_{jm}F_m + u_jU_j$$

where

Z_j is the variable in standard units; a_{ji} is the square root of the contribution of common factor F_i to the variance of Z_j, F_i being measured in standard units; m is the number of common factors; u_j is the square root of the contribution of unique factor U_j to the variance of Z_j.

This postulate attributes the variance in Z_j to two types of factors: common factors and a unique factor. Common factors are those which Z_j shares with other tests in the battery. The unique factor is specific to Z_j only; it arises from fortuitous variable errors, imperfections in the measuring instrument furnishing Z_j, and peculiarities unique to Z_j.

Holzinger (14:19) shows if a variable Z_j is correlated with any other variable Z_k in the set, the resulting correlation will have the composition

$$(2) \quad r_{jk} = a_{j_1}a_{k_1} + a_{j_2}a_{k_2} + \ldots\ldots + a_{jm}a_{km},$$

when the common factors are orthogonal. This expression also may be written in the matrix form $R = FF'$ where the a_j's form the entries of the rows and columns of matrices F and F', respectively. A variable correlated with itself will produce unity in the principal diagonal of R. From equation (2) it can be seen that the unique factors, being uncorrelated from test to test, are effective only in the principal diagonal and not in the side correlations of R. This is an extremely important property for the analyst who is interested only in analyzing the common factor variance of R. Depending upon the number of common factors, a factor matrix simpler than the test score ma-

trix will be obtained if the factor matrix is written with the u_j's omitted. This factor matrix will reproduce the side correlations in R only, and will fail to reproduce unity in the diagonal element unless the total variances of the tests are being analyzed. It can be seen that the analyst really is not attempting to duplicate the R obtained from the test scores which produce unities in the diagonal, but rather a correlation matrix possessing the same side correlations and with values in the principal diagonal which represent the common factor variances. These latter values, called "communalities," represent portions of the unit variances which exclude factors peculiar to individual tests. The analyst has to decide prior to factoring whether the purpose of his analyst demands utilization of the total variances of the variables or just their common factor variances. If the total variances are required, the analyst retains unities in the diagonal; if common factor variances are required, he inserts communalities. In the latter case, estimates must be made because communalities are not known at the start of the analysis. In large correlation matrices, usually the highest coefficient in each column suffices. With many variables, precise estimates are not crucial because adjustments may be made as the factoring proceeds.

The Multiple Group Method of Factoring

The multiple group method of factoring is the product of the efforts of several men. In 1944, Guttman (6) laid the theoretical groundwork by showing analytically that several factors could be extracted simultaneously. Later, in the same year, Holzinger (13) published a paper showing the computational procedure for the simultaneous extraction of several factors. Holzinger qualified his method, however, to correlation matrices which presented clusters of variables of unit rank. Shortly after, Thurstone (25, 27) showed that this method was general for any correlation matrix. Subsequently, Harris and Schmid (10) made some modifications in the computational and rotation procedure.

The multiple group method of factoring may be considered in the light of Thurstone's (26: Ch. VII) geometrical model wherein a configuration of test vectors existing in multi-dimensional space may represent a matrix of correlations of those test variables. Groups of variables are formed arbitrarily by sectioning the correlation matrix. A "centroid" or group axis is passed through each group of vectors (variables) forming a structure S of correlations of the variables with the axes. The factoring is completed by developing a matrix Φ of intercorrelations of these axes and a factor pattern matrix P. These operations are indicated by the operations:

$$R = SP'$$
$$\text{and} \quad P = S\Phi^{-1}$$

The pattern matrix may be interpreted several ways. Analytically, the pattern values for each variable are the a's of the expressed linear equation (1). Geometrically, any variable Z_j may be represented as a vector whose length and direction are determined by its coordinates. If the common factors are taken as reference axes, the coordinates of a vector are expressed by the pattern values of the variable. In general, common factors which satisfy a primary axes solution are correlated and therefore the reference axis system is oblique. Holzinger (14:Ch. XI) has made explicit the geometrical distinction between structure values and pattern values. In Figure 1, the pattern values, a_{j_1}

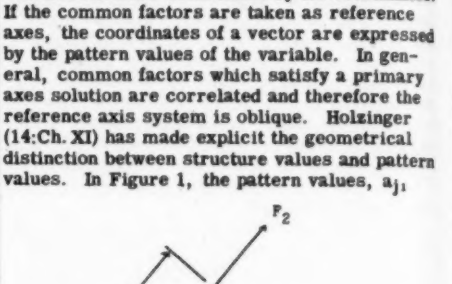


Figure 1

and a_{j_2}, are the coordinates of Z_j with respect to the oblique axes, F_1 and F_2. These coordinates are defined by axis intercepts of parallels from Z_j. The structure values, r_{j_1} and r_{j_2}, are the correlations of Z_j with the oblique axes. Geometrically, these values are the intercepts formed by constructing perpendiculars to the axes from Z_j. It may be seen that if the oblique axes were rotated to orthogonality, the structure values and the pattern values would become identical.

Simple Structure—Primary Axes

A correlation matrix may be factored into infinitely many paired product matrices; therefore, non-uniqueness of factoring poses the question of what type of solution to accept. This is most easily clarified by a geometrical approach. A coefficient of correlation may be represented by the cosine of the angle between two test vectors. A correlation matrix of order

n, therefore, may be represented by a configuration of test vectors lying in an n-space. If the rank of the matrix is lower than the order, these test vectors may be considered as being projected into a subspace of dimensionality equal to the rank of the matrix. This subspace is called the common factor space. The problem then becomes that of placing reference axes in this configuation of vectors to furnish a desired solution. Reference axes may be put among the vectors in an infinite number of positions. The factoring of the correlation matrix has resulted in a set of axes whose location is arbitrary and whose location may readily be changed merely by rotation, either rigidly or non-rigidly to a desired position. Originally, Thurstone sought to obtain simple structure by retaining the centroids orthogonal. In general, orthogonal simple structure cannot be obtained, and Thurstone has shown that simple structure may be secured by permitting the axes to become oblique (correlated). The mooted problem of what constitutes a satisfactory location of axes apparently has no singular answer, although Thurstone offers his concept of simple structure as an ideal. He believes that the factors of a solution should have psychological meaning as well as be invariant for different samples. After centroids are obtained, Thurstone rotates the axes to a position which maximizes the number of zero loadings and minimizes the bipolarity of the loadings.

These rotated reference axes, each of which are at right angles to a hyperplane containing a set of vectors, however, are not taken as the factors. Thurstone takes as the factors, which he calls "primary factors," the intersections of the hyperplanes. The rationale for this switching of dimensions lies in the arbitrary distinction between structure and pattern. A structure is a set of correlations of vectors with axes; a pattern is a coordinate system of vectors with axes. Simple structure is a true structure. However, Harris and Knoell (9) and Thomson (23: Ch. 18) have demonstrated the reciprocity between the structure on reference axes and pattern on primary axes. The structure values on the reference axes are proportional by columns to the pattern values on the primary axes. It seems that Thurstone is searching for a primary solution, although he interprets from the simple axis solution. Reciprocity between the two reference systems certainly seems to warrant this procedure.

Holzinger obtains directly a primary pattern merely by locating reference axes through groups of variables that will satisfy Thurstone's criterion of simplicity. Harris and Knoell (9) have shown that these pattern values are a linear function of Thurstone's simple structure values and consequently, there is no fundamental disparity between the two solutions.

The computational procedure will illustrate some of the principles discussed above.

Choice of the Factorial Method

The choice of the factorial method used was guided by the desire to obtain a primary pattern solution, or what is comparable, simple structure. Of the infinite number of solutions, simple structure is that solution for which the number of zero or near zero entries is maximized. The ambiguity of this criterion becomes apparent when an attempt is made to secure simple structure. Experience has shown that unless the primary axes can be identified in advance, rotational procedures will not lead necessarily to the desired simple structure. Harris (8) has formulated a geometrical criterion for certain types of desired factor patterns that may make identification of the primary axes in many problems more precise. This criterion was used in the analyses of this investigation and will be discussed subsequently.

An oblique solution on primary axes presents the variables reduced to lowest complexity. The advantage gained with this type solution lies in the interpretation that may be made about the sample and the factors. When a test is of complexity two or greater, there is no way of determining whether each factor samples all or just some of the students supplying the numerical data. Frequently, a primary solution presents variables of complexity one, thus eliminating this indeterminativeness.

In carrying out factor analyses on the female and male groups, Harris's (10) modified form of the multiple group method of factoring was used. This procedure essentially entails four steps:

1. Estimation of communalities
2. Determination of the number of common factors
3. Construction of an arbitrary initial oblique structure
4. Rotation of this initial structure to a primary axes solution

In addition to reducing the amount of computation, Harris's procedure offers several advantages. If the communality estimates are reasonably accurate, a geometrical criterion is available for determining the number of common factors. Harris (8) has demonstrated that the factor problem may be described in terms of the geometry of the hypertetrahedron; that is, he postulated that an m-space hypertetrahedron might serve as a model for an m-common factor test configuration. If a variable is of complexity one, it locates a vertex of the model. Complexity two indicates a variable resident in a plane spanning two primary axes of the model; complexity three indicates

a variable lying in a 3-space hyperplane of the model; complexity four indicates that the variable lies in a 4-space hyperplane. This may be generalized on up to the complete dimensionality of the problem. If the structure values for all the variables are extended to unity on one of the group axes, and if orthogonal plots of the extended structure values are made on remaining pairs of axes, the m-space test configuration is delineated as a plane representation wherein the m-space dimensionality is revealed as vertices and regions of higher complexity. The number of common factors is indicated by the number of vertices which from plot to plot consistently are defined as the intersections of lines formed by the same sets of variables.

The number of common factors always has presented a formidable problem to the factor analyst because sampling errors of the correlations disguise the rank of the correlation matrix. Reproduction of correlations and examination of the size of the residual correlations is not a satisfactory answer because the distribution of r is skewed; and, in addition, the sampling errors in the original correlations are intercorrelated. Other criteria have been proposed by Tucker (24:66-7), Coombs (2), McNemar (18), and Swineford (22: 377); but to date the problem has not been solved satisfactorily.

An upper limit to the number of common factors frequently may be determined if the communality estimates are good. In the process of factoring, an arbitrary number of factors are extracted and a matrix ϕ of intercorrelations of these factors is obtained. ϕ is obtained from the correlation matrix by a series of elementary transformations, and consequently the rank of ϕ equals the rank of R. If the inverse of ϕ cannot be computed because some of the pivotal values become negative, or if the pivotal values approach a zero value, thus causing the entries of ϕ^{-1} to become many times larger than unity, then linear dependence exists between the arrays of ϕ. Linear dependence of arrays arises fortuitously by construction if the initial oblique axes are linearly dependent. This dependence of axes may be eliminated by regrouping the variables to form a new reference frame. With experimental data, however, linear dependence arises almost always if too many common factors have been extracted so that several are forced into dependence. Linear dependence results in the rank of ϕ being less than its order and its determinant being zero. This indicates that R is of lower rank also, and there are less common factors than the order of ϕ. The computation of ϕ^{-1} as a test of the number of common factors rests on the definition of the inverse. Each element of an inverse is obtained by dividing an appropriate value by the value of the determinant of ϕ. If the determinant of ϕ is zero, ϕ is said to be singular, and the division process leads to meaningless values.

Harris's geometrical criterion of the dimensionality of the common factor space and the inverse test show promise as important aids for many factor problems.

The computational procedure in making the analyses perhaps will clarify aspects of the multiple group method described in the previous exposition. At appropriate steps of the analyses, further consideration will be given to some of these concepts.

SECTION II

SUBJECTS - MEASURES

Description of the Subjects

Data were obtained on 102 students who were enrolled in the School of Education at the University of Wisconsin during 1947-48. The selection of these 102 cases was made on the basis of completeness of data for each student. The 102 cases consisted of two equal groups of male and female students. All of the measures except the professional and total grade point averages were obtained after the students had graduated.

Measures Used

Twenty-four variables were used in these analyses. Seven variables were derived from the Washburne Social Adjustment Inventory; seven were derived from the Mooney Problem Check List; and four scales of the Minnesota Multiphasic Personality Inventory were used. The remaining six variables were individual measures obtained from the student files.

The twenty-four variables are listed below. The code number preceding each measure is used to identify that measure as the variable in the correlation and factor tables. A code symbol follows each measure.

(1) Control	C	(Washburne)
(2) Purpose	P	(Washburne)
(3) Sympathy	S	(Washburne)
(4) Alienation	A	(Washburne)
(5) Impulse-Judgment	I	(Washburne)
(6) Subtotal score	WT	(Washburne)
(7) Yes-response	Y	(Washburne)
(8) Professional Grade Point Average	PGPA	
(9) Total Grade Point Average	TGPA	
(10) Best Teacher Attitude Test	BTAT	
(11) Age	M	
(12) Finances, Living		

Conditions, and Employment	FLE	(Mooney)
(13) Social and Recreational Activities	SRA	(Mooney)
(14) Social-Psychological Relations	SPR	(Mooney)
(15) Personal-Psychological Relations	PPR	(Mooney)
(16) Adjustment to College Work	ACW	(Mooney)
(17) The Future: Vocational and Educational	FVE	(Mooney)
(24) Mooney Total Score	MTS	(Mooney)
(18) Practice Teaching Rating	PTR	
(19) Hypomania	Ma	(Minnesota)
(20) Masculinity-Femininity Interest	Mf	(Minnesota)
(21) Depression	D	(Minnesota)
(22) Social Introversion-Extroversion	IE	(Minnesota)
(23) Wright Professional Judgment Examination	WPJE	

Description of the Measures

1. Washburne Social-Adjustment Inventory, WSAI (Thaspic Edition), J. N. Washburne, Syracuse University, Syracuse, New York. This inventory is an eight-page booklet containing 122 questions concerning the examinee's likes, dislikes, habits, beliefs, wishes, ideals, and moods. Most of the questions call for a single response, "Yes" or "No". The inventory is intended to furnish a measure of an individual's social and emotional adjustment relative to six traits: happiness, alienation, sympathy, purpose, impulse-judgment, and control. A "truthfulness" scale is included to indicate a degree of inaccuracies, intentional or otherwise, in answering the items.

The seven measures that were selected from this instrument are described below:

a. Control - C. This is a subtest of the WSAI consisting of seventeen items. This subtest attempts to measure that quality which might be described as "self-control" or "the ability to make and execute plans." A low score indicates satisfactory adjustment.

b. Purpose - P. The thirty-two questions in this subtest attempt to measure "desire definitely directed toward a goal involving plan, evaluation, selection, and effort." A low score indicates satisfactory adjustment.

c. Sympathy - S. Twenty-seven items are designed to measure a personality trait which might best be described as a sympathetic attitude towards people and animals. A low score indicates satisfactory adjustment.

d. Alienation - A. The twenty items in this subtest measure what might be considered as "a sense of social membership and acceptance." A low score indicates satisfactory adjustment.

e. Impulse-Judgment - I. Nine items are intended to measure the ability of a person to control impulses that are attended by satisfaction deemed less worthy but immediate in favor of more promising but remote outcomes. A low score indicates satisfactory adjustment.

f. Subtotal Score - WT. This score used in the study differs from the subtotal score listed on the profile chart of the WSAI. A composite score was made of the six traits: happiness, alienation, sympathy, purpose, impulse-judgment, and control. A low score indicates satisfactory adjustment relative to the composite of these traits.

g. Yes-response - Y. The tendency to give a yes-response to questions of the WSAI was investigated by counting the number of "yes" responses made by each student. It was believed that a response set might be related to the practice teaching grade. If this were true, the validity of the practice teaching grade might seriously be questioned.

2. Professional Grade Point Average - PGPA. This measure was secured by averaging each student's grades in education courses. Generally, this measure was a composite of four grades. The grades were taken from Education 73, 74, 75, and methods courses. A high score indicates good grades.

3. Total Grade Point Average. - TGPA. This measure was the student's total grade point average upon graduation. A high score indicates good grades.

4. Best's Teacher Attitude Test - BTAT. This test, developed at the School of Education of the University of Wisconsin, furnishes a measure of the student's attitude toward teaching and the teaching profession. One hundred stated generalizations representing opinions about teachers and the teaching profession are listed. The examinee may respond in one of five ways: agree, inclined to agree, cannot say, inclined to disagree, and disagree. A high

score indicates favorable impressions or attitudes toward teachers and the teaching profession.

5. Age - M.

6. Mooney Problem Check List - MPC (College Form). Ross L. Mooney; Ohio State University, Columbus, Ohio. This checklist consists of 330 stated problems that college students might feel were of concern to them. These problems are classified into eleven areas—thirty problems in each area. The student is asked to underline those problems that seem of concern to him, and of these, to encircle the problems that seem of greatest concern. It would have been desirable to include all eleven areas in these analyses, but this was precluded by the scope of the analyses. Six of the areas were regarded as being most significant in this study. The number of problems underlined in each area was taken as a measure of personality relative to that area. It was believed that the number of problems of concern to a student in the area of social-psychological relations, for example, served as a partial index of that student's lack of adjustment in this area.

The seven variables that were derived from this checklist are:

a. Finances, Living Conditions, and Employment	FLE
b. Social and Recreational Activities	SRA
c. Social-Psychological Relations	SPR
d. Personal-Psychological Relations	PPR
e. Adjustment to College Work	ACW
f. The Future: Vocational and Educational	FVE
g. Total number of problems in all areas	MTS

7. Practice Teaching Rating - PTR. Each practice teacher is rated on seventeen items. As a person, he is rated on poise, appearance, speech, and social form. As a student, he is rated on knowledge of subject matter, breadth of experience, educational principles, and professional ambitions. As a group leader, he is rated on his ability to motivate pupils, theory and practice, group control, organization of materials, and initiative. As an adviser to individuals, he is rated on matters related to ability to gain pupil confidence, aid in remedial work, pupil conferences, and guidance. A student is rated after a semester of practice teaching experience by a critic teacher of the University of Wisconsin High School.

A composite score was made from the seventeen items. A low score indicates good teaching skill.

8. Minnesota Multiphasic Personality Inventory MMPI. S. R. Hathaway and J. C. McKinley, University of Minnesota, Minneapolis, Minnesota. The Minnesota Multiphasic Personality Inventory is an instrument designed to measure psychological and psychiatric phases of personality. Five hundred and fifty statements, covering health, habits, attitudes, education, and the like, are printed on separate cards. The examinee is asked to sort the cards into three categories: "True", "False", or "Cannot say" as the statements refer to him. On the basis of these statements, four validating and ten personality scales were devised by Hathaway and McKinley (12) at the University of Minnesota. These scales are named hypochondriasis, depression, hysteria, psychopathic personality, masculinity-feminity, paranoia, psychasthenia, schizophrenia, and hypomania. Drake (3, 4) at the University of Wisconsin developed another scale which he named "Social Introversion-Extroversion."

a. Hypomania - MA. This scale measures a personality characteristic typical of persons who try to do too many things simultaneously. These people are characterized by overactivity in thought and action. Two studies indicate that hypomania may be characteristic of students. Lough (17) states that 185 unmarried women teacher college students showed a tendency toward hypomania on the inventory: Lough suggests that certain scales might be useful in the selection of teachers. Blum (1) found hypomania more characteristic of students training for professions in medicine, journalism, law, or mechanical engineering. High scores lie in the direction of abnormality.

b. Masculinity-Femininity Interest - Mf. A high score on this scale indicates a deviation in interest pattern in the direction of the opposite sex.

c. Social Introversion-Extroversion - IE. This scale was developed by Drake (3, 4) at the University of Wisconsin. Drake made an item analysis of MMPI responses differentiating students who attained centile ranks above sixty-five and below thirty-five on the Minnesota T-S-E Inventory. Items showing a difference of two standard deviations of the difference between the percentage of responses of the upper and lower groups were

taken as the Social Introversion-Extroversion scale. This scale was validated against students' participation in school and extra-curricular activities. A high score indicates a deviation in the direction of introversion.

d. Depression - D. A high D score indicates a person characterized by depression, low morale, lack of an optimistic attitude toward life. This scale might serve as a description of the syndrome of confusion and worry factor of the Marzolf and Larsen (19) study.

9. K Validating Scale. A common failing of personality tests is their susceptibility to deception. Some examinees, consciously or unconsciously, attempt to present aspects of themselves that are not necessarily accurate. This impinges directly upon the validity of the test. Meehl and Hathaway (21) developed the K validating scale for the Minnesota Multiphasic Personality Inventory. This scale is an attempt to correct this inadequacy by sharpening the discriminative power of the other scales. The four scales used in this study have been corrected with the K scale.

10. Wright Professional Judgment Examination WPJE. This examination, developed at the School of Education of the University of Wisconsin, attempts to measure a student's judgment in selecting sound teaching techniques under special conditions. The examination calls for multiple choice responses to described learning-teaching situations. Twelve test exercises describe special teaching situations. Ten possible techniques are provided. The student is asked to indicate one preferred technique and one optional technique. Reasons for these choices are indicated by checking items from lists of general conditions, special conditions, principles that the student may hold to be true, and general objectives of education. These lists were given to the students several days in advance. A high score is indicative of good professional judgment.

11. The extreme scores, ranges, means, standard deviations, and the number of students for which the twenty-four measures are obtained are presented in Table I. This table also furnishes further description of the students used in these analyses.

Limitations of the Data

Complete data for each individual were not available. It did not seem feasible to eliminate cases for which certain measures were missing and thus reduce the size of the sample below what would seem a desirable limit; therefore, all cases were retained. This necessitated using correlations based on varying subgroups. It is true, as Holzinger and Swineford (15:5) point out, that correlations obtained in this manner cannot accurately be treated as comparable sets, but this limitation may be less demanding in certain circumstances. The comparability of varying subsamples depends largely on the homogeneity of the supply sample. If the supply sample is relatively homogeneous with respect to influences that might disturb the coefficients of correlations of the experimental variables, then comparability of subsamples are assured. Homogeneity of the cases was ensured partly through the design of the study and partly through the nature of the supply sample used. The 102 cases were divided equally into male and female groups. All the students were white. Although the ages ranged from nineteen through thirty-nine years, the standard deviation of 2.7 years indicated that the variability of age was not great. The students were of the same educational level by virtue of their being seniors and second semester juniors. A grade point average of 1.3 is necessary for admission to the School of Education after two years of college education. This selectivity was a contributing factor to the homogeneity of the scholastic achievement and educational level of the students in the study. Thus, heterogeneity within the supply sample was minimized relative to sex, race, age, vocational aspiration, and educational and scholastic levels.

A second consideration which suggested the use of varying subsamples rather than a very small but consistent sample was prompted by inferences made about factor loadings. Harsh (11), in showing that factor loadings are more stable than the correlations on which they are based, points out that the reliability of factor loadings is dependent on the number of variables and the size of the sample. This is a logical consequence of the derivation of factor loadings from pooled coefficients of correlations. The greater the number of variables used (and, accordingly, the larger the pool of correlations), the greater the reliability of the factor loadings. Also, the reliability of a correlation coefficient is dependent upon the size of the sample. From these and other considerations, Harsh concluded that greater flexibility might be made of factor methods.

The plausibility of using data that were not entirely complete, but comprehending more variables and individuals, seemed justified in view of the homogeneity within the supply sample on major factors and in view of the relative stability of factor loadings.

Another limitation which must be considered when making inferences about the factor loadings is the time interval over which the personality measures were obtained. The per-

TABLE I

EXTREMES, RANGES. MEANS, STANDARD DEVIATIONS, AND NUMBER OF CASES OF THE TWENTY-FOUR MEASURES

Variable	Code	High Score	Low Score	Range	Mean	S. D.	No.
1	C	35	0	35	7.5	8.0	97
2	P	63	21	42	37.8	9.1	97
3	S	31	0	31	10.6	7.7	97
4	A	31	1	30	9.2	6.9	97
5	I	13	0	13	2.6	2.8	97
6	WT	144	30	114	78.7	18.0	97
7	Y	55	25	30	37.9	6.7	97
8	PGPA	3.00	0.82	2.18	2.24	0.39	101
9	TGPA	2.92	0.96	1.96	1.75	0.40	91
10	BTAT	90.7	11.4	79.3	49.4	17.0	97
11	M	39	19	20	23.3	2.7	101
12	FLE	22	0	22	2.6	3.4	80
13	SRA	19	0	19	2.8	3.0	80
14	SPR	11	0	11	1.2	2.1	80
15	PPR	12	0	12	2.0	2.6	80
16	ACW	13	0	13	2.5	2.9	80
17	FVE	10	0	10	1.7	2.1	80
18	PTR	3.00	1.00	2.00	2.04	0.40	89
19	Ma	78	35	43	56.3	9.7	88
20	Mf	76	34	42	55.0	9.9	88
21	D	75	29	46	47.8	8.7	88
22	IE	68	28	40	43.7	8.1	88
23	WPJE	3.00	0.00	3.00	1.82	0.90	100
24	MTS	32	0	32	5.4	6.3	80

sonality tests were administered to the students over a period of several months. The effects of this time lapse were not determinable with the design of this study.

Treatment of the Scores

The data for each individual were recorded on an IBM card. In order that each of the twenty-four variables could be represented as a column on the cards, the raw scores were coded into nine class intervals. The definitive nature of the distribution of age prescribed a linear transformation to a nine interval scale in order to preserve the shape of the distribution. The shapes of the distributions of the other traits, however, being contingent upon scoring and scaling procedures, specific nature of the tests measuring those traits, conditions under which the tests were administered, and the sample of students, were experimentally indeterminable. Therefore, these distributions were normalized in accordance with Thurstone's (26:367-9) recommendation. Thurstone empirically found that although factor solutions utilizing the same raw scores subjected to different transformations yield essentially the same complete simple structure, the structure was rendered most clearly when the raw scores were normalized.

The raw score distributions were normalized by expressing each frequency of a distribution as a percentage of the total frequency of that distribution. The average sigma distance of these percentages from the mean of the raw score distribution determined the code number. Each code number represented an interval of 0.67 sigma units on the base line under the normal curve. The code numbers ranged from 1 to 9 with 5 spanning the mean section of the normal curve. Table XXVII in Garrett (5:166-7) was found to be useful in the normalizing procedure.

SECTION IV

FACTOR ANALYSIS OF FEMALE SCORES

The numerical data and matrices used to develop the solution for the female scores are presented in Appendix A.* Capital letters denote matrices, arrays of matrices, and group axes. References to these symbols will be made in context to prevent confusion. Subscripts attached to the letters indicate the stage of development of the factorial solution.

Intercorrelations of the Female Scores

The sums, sums of squares, and sums of cross products were calculated on an IBM tabulator. The product moment coefficients of correlations subsequently were computed on desk calculators. The intercorrelations of the twenty-four variables of the female group appear below the principal diagonal in matrix R_F. (Table A1).** Variables 8, 9, 10, and 11 have been reflected in order to maximize the number of positive correlations. The numbers of cases on which these correlations are based appear in the upper half of R_F. Further references to R_F will relate only to the total correlations of this matrix.

Initial Estimates of Communalities

Estimates of communalities were made by grouping tests and applying the centroid formula. Medland (20) empirically compared nine methods of estimating communalities, and he found that the centroid method furnished the most consistent results. Three to five tests most highly intercorrelated are grouped with the test whose communality is to be estimated. The highest r in each column is placed in the diagonal of this group matrix, and the centroid is extracted. The square of the resulting "factor loading" for the specified test is taken as the estimate of the communality. Estimates of communalities CE_1 (Table A2) were obtained in this manner for the twenty-four variables. These estimates were placed in the diagonal of R_F.

Determination of the Number of Common Factors

R_F was sectioned into three groups:

Group A_1: 1 - 7
Group B_1: 8 - 10, 12 - 18, 24
Group C_1: 11, 19 - 23

Although the sectioning was arbitrary, care was taken to form one group that would eventuate in a group axis positively correlated with all of the variables.

The correlations of each variable were summed over the three groups to produce G_1. This summation process may be considered as a matrix transformation. A matrix E can be constructed which has zero and unity elements so arranged that postmultiplying R_F by E selects the appropriate correlations to form G_1.

*All references to Appendices may be found in original thesis on file in the Library, University of Wisconsin.

**All references to lettered tables may be found in Appendices of original thesis on file in the Library, University of Wisconsin.

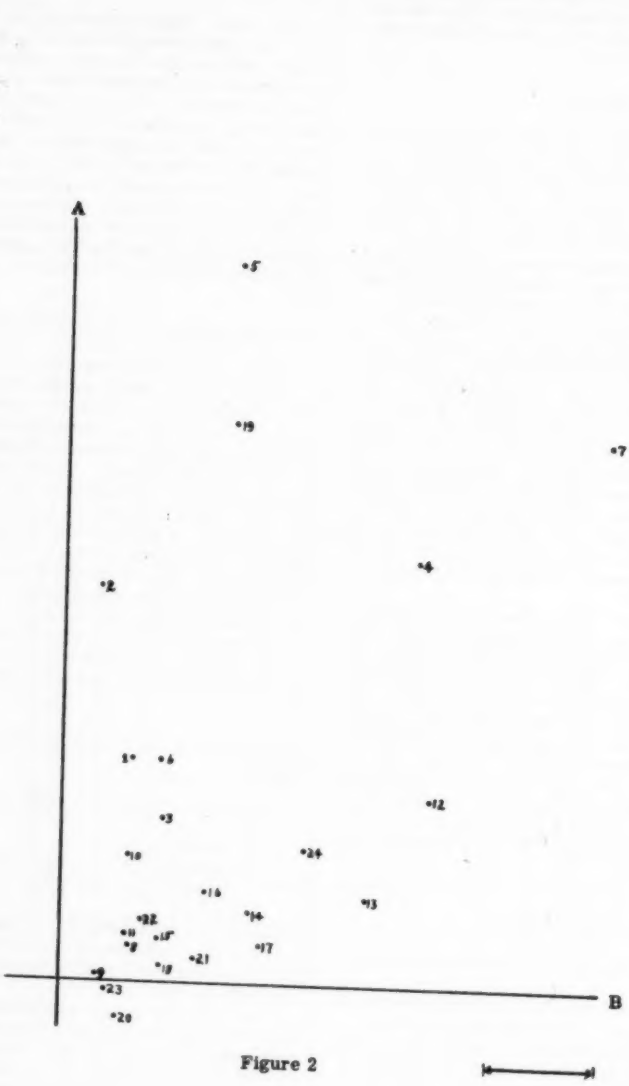


Figure 2

The sums of correlations of each group with every other group, H_1, were obtained by summing the columns of G_1 over each group. This operation was equivalent to premultiplying G_1 by E'. A diagonal matrix W_1 was constructed from the reciprocal square roots of the principal diagonal elements of H_1. A structure value is derived from a summation value of a G matrix by dividing the summation value by the length of the group axis. The length of a group axis is given by the square root of the appropriate principal diagonal element in H_1. The structure S_1 was obtained from G_1 in a single operation by premultiplying G_1 by W_1. The structure values represent the correlations of the variables with the group axes. Geometrically, these operations served to pass a reference or group axis through each group of variables. No restrictions were made as to orthogonality, and these axes ordinarily will be oblique unless fortuitously orthogonal. The angles separating the group axes may be determined from their intercorrelations given in ϕ_1. ϕ_1 was computed by pre- and postmultiplying H_1 by W_1. ϕ_1^{-1} was computed by the Gaussian method of substitution employing the Doolittle worksheet procedure. The entries of ϕ_1^{-1} were sufficiently small to indicate that linear dependence did not exist between the arrays of ϕ_1.

This initial oblique structure was constructed only for the purpose of attempting to determine the dimensionality of the common factor space by examining a plane representation of the test configuration. The structure values were extended to unity on the Group C_1 axis by dividing the structure values of each variable by the respective C_1 axis structure value. These extended values are shown in matrix M_1. An orthogonal plot (Figure 2) was made of the A and B group axes' extended values. The configuration revealed no clear profile. Therefore, it was decided to construct a four axes structure and examine the resulting three plots from the extended structure values.

R_F was resectioned into four groups:

Group A_2: 7, 12, 13, 17, 24
Group B_2: 8, 9, 10, 11, 20, 23
Group C_2: 4, 6, 14, 15, 16, 18, 21, 22
Group D_2: 1, 2, 3, 6, 19

Structure values were computed in the routine manner described for three axes. It should be noted that variable 6 in S_2 has a structure value which is greater than unity. Although a correlation coefficient theoretically cannot exceed unity, this structure value is computationally correct because of the nature of the variable. Variable 6 is a composite score of the subtest scores of the WSAI. Experience has shown that composite variables frequently exhibit this property as well as communalities greater than unity.

The structure values were extended to unity on the Group C_2 axis. (See matrix M_2). Three orthogonal plots were necessary for complete profile representation of the test configuration - one plot for each pair of axes excluding the axis which was taken at unit length. These plots are shown in Figures 3, 4, and 5. In the examination of the extended vector plots, several clues are useful in identifying the dimensionality of the test configuration. In general, variables having low communalities should be disregarded as they have unstable extended values. Variables or groups of variables which do not have low communalities and which remain on the periphery of the configuration from plot to plot, may identify the regions of complexity two of the hypertetrahedron; the intersection of these lines, in turn, define the extensions of the primary axes.

Harris (8) has shown that a m-space hypertetrahedron should project on a plane as a configuration having m vertices. Taking variables 2, 9, 19, and the cluster (12-17, 24) as vertices, six lines outlined a configuration having four vertices. This indicated the presence of four common factors. However, the consistent intersection of the diagonal lines in the region of variables 3 and 10 strongly suggested a fifth vertex and, therefore, five common factors.

The inverse test on the four axes system of intercorrelations tended to negate the hypothesis of five factors. O_2^{-1} was computed as before. The C_2 diagonal value exceeded unity by a multiple greater than four (See Table A6). This indicated that perhaps four common factors were excessive. Nevertheless, the plotted configuration had suggested the possibility of five factors, so this contradiction was temporarily discarded.

In testing the hypothesis of five common factors, new communality estimates CE_2 (Table A6) were obtained by reproducing the principal diagonal elements of the correlation matrix with the four group factors. Reproduction of the diagonal values was carried out in accordance with the relationship $R = SP'$. P_2 was obtained by the operation $S_2O_2^{-1} = P_2$. The reproduced diagonal elements of the correlation matrix, shown in Table A7 were taken as new communality estimates CE_2, with the exception of the value for Variable 6. The reproduced valued exceeded unity; therefore, the communality estimate arbitrarily was taken as 0.99.

R_F was sectioned into five groups:

Group A_3: 7, 12, 13, 24
Group B_3: 4, 8, 10, 16, 17, 18
Group C_3: 9, 11, 20, 23
Group D_3: 6, 14, 15, 21, 22
Group E_3: 1, 2, 3, 5, 19

Extended vector plots were made in the manner previously described; however this time,

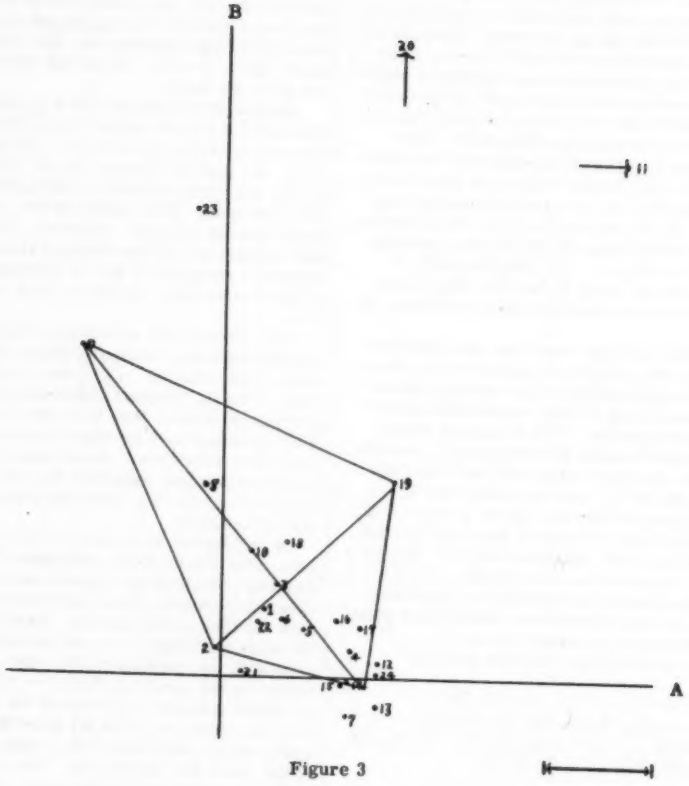


Figure 3

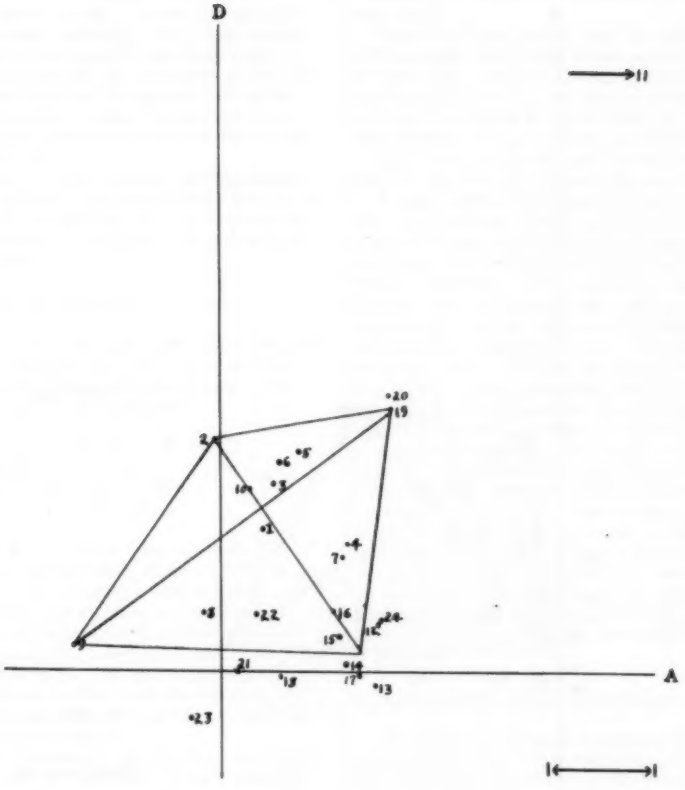


Figure 4

Figure 5

Group axis B_3 was extended to unity. Six plots were available for examination: Figures 6, 7, 8, 9, 10, and 11. The number of plots that may be made available are equal to the number of paired extended axes, excluding the axis taken at unit length. If n factors are extracted, there will be $\frac{(n-1)(n-2)}{2}$ pairs of axes.

Examination of the six plots seemed to indicate the presence of four factors only. Variables 15, 2, 13, and 20-23 appeared consistently as indicators of four axes. ϕ_3^{-1} was computed for the five groups of variables. Most of the entries of ϕ_3^{-1} were appreciably greater than unity indicting linear dependence between some of the group reference axes. This does not preclude the existence of five independent common factors because grouping may have resulted in linear dependence; but this eventuality seemed unlikely in view of the test configuration.

On the basis of the criteria, test configuration of the extended structure values and the inverse test, the hypothesis of five common factors was discarded, and four common factors were postulated.

Arbitrary Oblique Solution

Variable 9 was reflected back to its original direction, leaving 8, 10, and 11 the only variables reflected to their original sense. The correlation matrix was grouped:

Group A_4 : 7, 8, 12 - 17, 24
Group B_4 : 1 - 6, 10
Group C_4 : 9, 18, 21, 22
Group D_4 : 11, 19, 20, 23

Extended vector plots were made at this stage from the extended G_4 values. This is possible because the structure values are linear functions of the summations of correlations values. The G_4 values were extended to unity on the group axis A_4 (See M_4). The three plots shown in Figures 12, 13, and 14 indicated the presence of four factors with variables 9, 10, 20, and 13 designating the vertices of the projected hypertetrahedron.

ϕ_4^{-1} was computed. Its entries were commensurate with the postulate of four common factors indicated by the plots. S_4 was calculated and taken as the desired initial oblique solution.

Rotation to Primary Structure

Examination of the plots of the extended G_4 values suggested that variables 9, 10, 20, and 13 representing clusters might be considered as the loci of the extended primary axes. Harris (7, 10) has demonstrated that when the primary axes are located, direct rotation may be made to primary structure. The structure values of the four variables were written as the rows of a matrix X of correlations of the primary axes with respect to the group axes. The operation $X\phi^{-1}$ produced a matrix Y of coordinates of the primary axes with respect to the group axes. A matrix Z of intercorrelations of the primary axes, taken at lengths determined by the entries in X, was obtained by the operation YX'. Pre- and postmultiplying Z by a diagonal matrix L formed from the reciprocal square roots of the principal diagonal elements of Z produced a matrix Φ_P of proper intercorrelations of the primary axes taken at unit length.

Harris (10) has shown that the matrix A which rotates the initial group axis structure into primary structure is constructed by postmultiplying Y' by L. Inasmuch as the entries in A are the ratios of coordinates of vectors to their lengths, A is a matrix of direction ratios.

Φ_P^{-1} was computed; and by the operation $S_P\phi^{-1}$, the primary pattern P_P was obtained.

A final check on the validity of the postulate that four common factors would satisfactorily explain original correlations was made by reproducing the correlation matrix and examining the residuals. The residuals, $R_{F\text{-res}}$ (Table A19), contained some values which were quite large, but all were within what might be attributed to sampling error. The mean of the residuals was 0.002 and the standard deviation was 0.123. The standard deviation of a zero correlation coefficient based on 51 cases is about 0.140. The number of cases on which the original correlations were based varied from 33 to 51; therefore, the standard deviation of a corresponding zero correlation generally would be greater than 0.140. The standard deviation of the residuals being less than 0.140 roughly indicated that further linkages necessarily did not exist between the variables. Undoubtedly, the fit might have been improved had the factoring process been reiterated several times using adjusted communalities until the communalities stabilized.

Interpretation of the Female Factor Matrix

The primary solution yielded a structure Sp and a pattern Pp. The columns in Sp may be considered as representing Thurstone's simple axis reference system, and the columns in Pp may be considered as representing what Thurstone calls the primary factors. Ordinarily, inferences about the nature of the common factors proceeds by observing which variables have significant values in any one column of the primary pattern matrix. The significant values in a column serve as a basis for inferring that some property common to the corresponding variables is responsible for the systematic correlations in the correlation matrix. The common property identifies the nature of the pri-

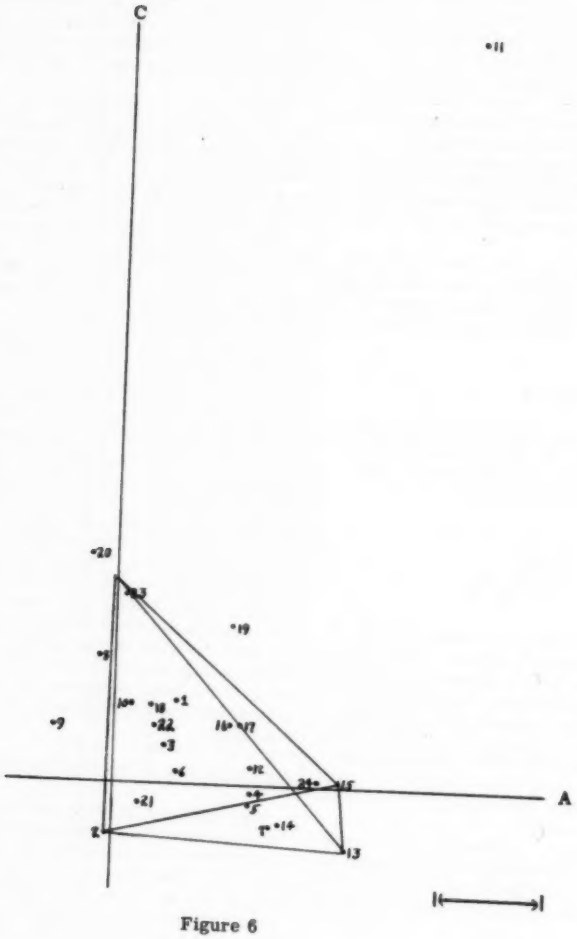


Figure 6

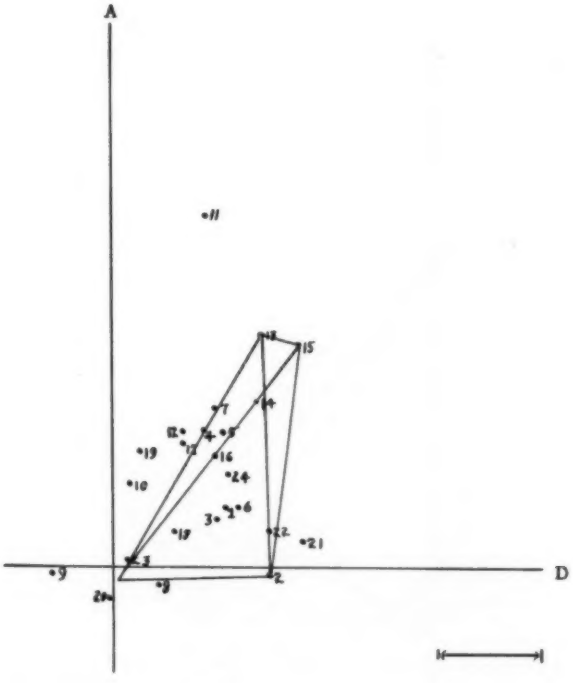


Figure 7

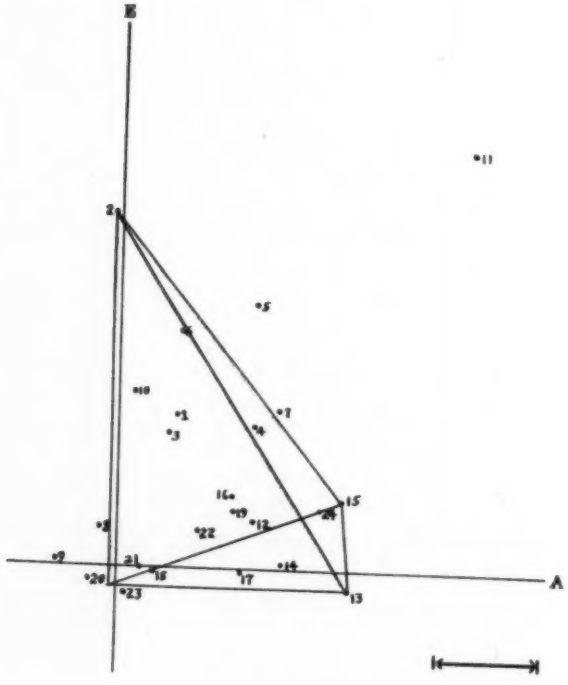


Figure 8

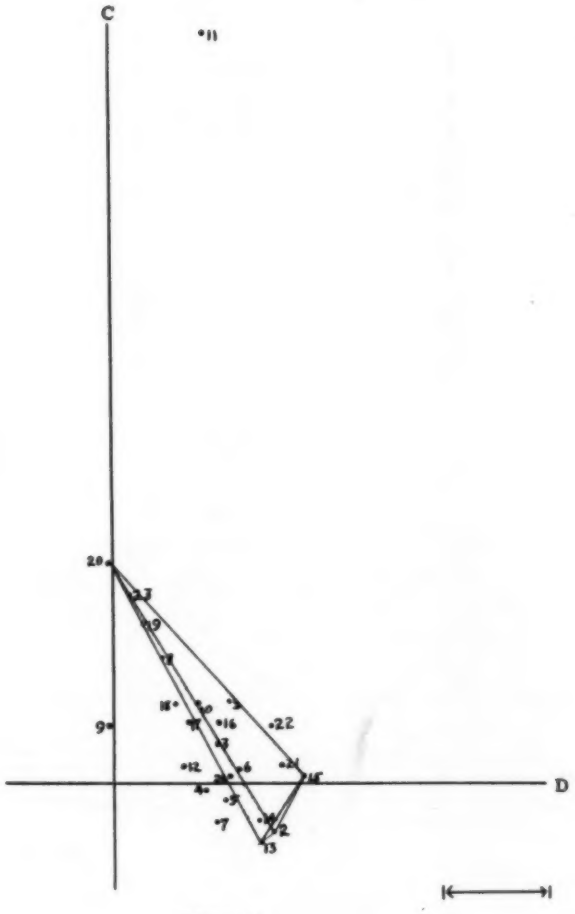


Figure 9

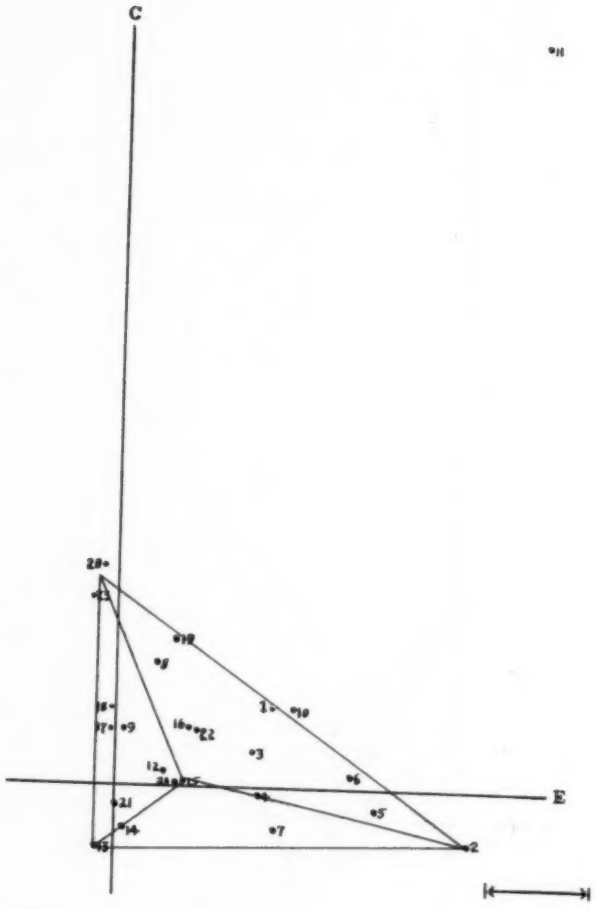


Figure 10

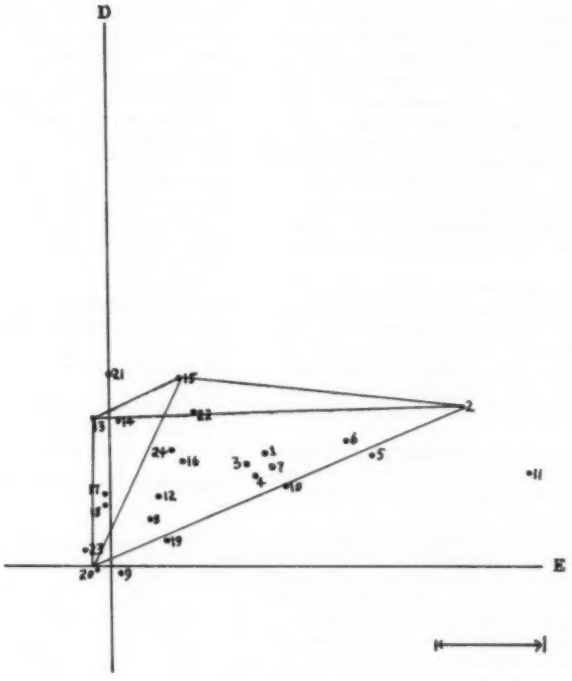


Figure 11

mary factor. Obviously, sundry properties might be common to the variables, but presuming that the variables have been derived by valid measuring instruments, the common property is the trait measured or that trait which offers the most meaningful explanation. The term "primary" as applied to common factors purports only a mathematical meaning and nothing in the sense that the factor is basic or elemental. Anything that systematically produces correlations, however complex, may become a primary factor.

A second consideration in making inferences about the common factors involves the complexities of the variables. The complexity of a variable is indicated by its number of significant pattern values. When simple structure has been obtained, the number of near zero values are maximized and thereby the complexities of the variables are minimized. This is highly desirable, for when a variable has complexity greater than one, several factors contribute to the variance of the variable. This dispersion among several factors makes the interpretation of the nature of the factors difficult. When a variable is of complexity one, only one common factor is assumed to contribute to the variance, and the remaining variance is attributed to peculiarities of the measuring instrument.

Ease of interpretation is gained also if the signs of all of the values can be made positive. A factor which contains both positive and negative values indicates that the commonness is bipolar, such as, extrovertive-introvertive, brave-cowardly, etc. Whether such qualities lie at the opposite ends of a continuum is questionable.

It can be seen that interpretation of a factor matrix is a highly speculative process and that inferences drawn may vary considerably with different examiners.

These considerations suggested that in the present analysis interpretation of the common factors was preferable if made from the rotated structure matrix Sp rather than from the rotated pattern Pp. Ordinarily, when a primary axis solution is obtained as in this problem, it is the pattern which exhibits the properties of simple structure outlined by Thurstone. In the present analysis, however, comparison of Sp and Pp leaves no doubt that Sp is the "neater" solution. The variables in Sp show lower complexity than those in Pp, and the bipolarity may be completely removed from Sp by reflecting variables 9 and 19, whereas no amount of reflections will do this in Pp. The writer can offer no explanation why the rotated primary structure matrix appears "simpler" than the pattern matrix other than that it may be an outgrowth of the polarity existing within the original correlation matrix after the number of positive coefficients have been maximized by reflection. Inspection of R_F shows that reflection cannot make all of the coefficients positive, and that a sizeable number of negative coefficients remain after variables 8, 9, 10, and 11 had been reflected.

In using Sp as a source for interpreting, the common factors should be designated as "simple factors" to distinguish them from "primary factors." However, in this analysis, the labelling is arbitrary. The values in Sp will be called loadings in the remainder of this chapter. What may be considered as significant loadings in any column also is arbitrary. The relative magnitudes of the loadings indicate which variables may be considered as confluent. Thurstone (24:79) regards loadings below 0.20 or 0.30 unstable because they represent a factor's contribution to the variance of the test which is less than 10 percent. In this study, 0.30 was taken as the minimal loading indicating a factor's contribution to the variance of a test. The loadings in Sp were rounded to two decimal places and those having values greater than 0.30 were recorded in matrix Vp (Table A21). In Vp, variables 9 and 19 have been reflected. It will be recalled that variable 9 now has been reflected twice so that it possesses its original sense. Variable 19, being reflected once, indicates lack of overactivity and productivity.

The matrix Θ of the intercorrelations of the factors (Table A20) represented in Vp were obtained by pre- and postmultiplying Φ_P^{-1} by a diagonal matrix constructed from the reciprocal square roots of the principal diagonal elements of Φ_P^{-1}.

The following inferences made about the factors must be considered in light of the limitations of the data previously stated.

Common Factor: (PRS) Problems Response Set

The variables having significant loadings on this factor are as follows:

4	(A)	.41
7	(Y)	.43
12	(FLE)	.62
13	(SRA)	.78
14	(SPR)	.78
15	(PPR)	.52
16	(ACW)	.66
17	(FCE)	.59
24	(MTS)	.89

(SPR) of this set is of complexity two, but its highest loading occurs on this factor. (D) and (IE) also possess loadings on this factor, but they have higher loadings in other columns. The loadings suggest two hypotheses: (1) the factor is an affirmative response set to any stated problem; (2) the factor is a response set to felt problems.

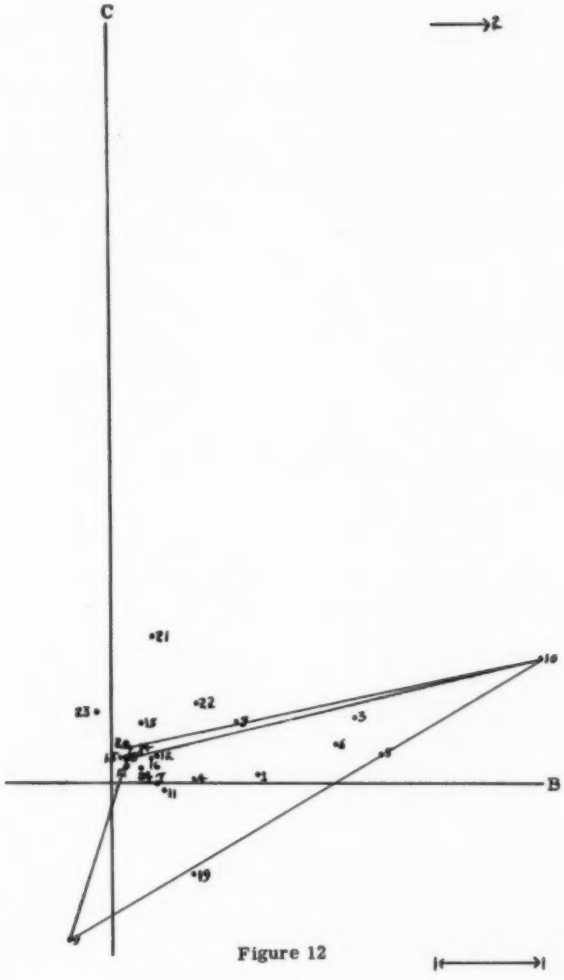


Figure 12

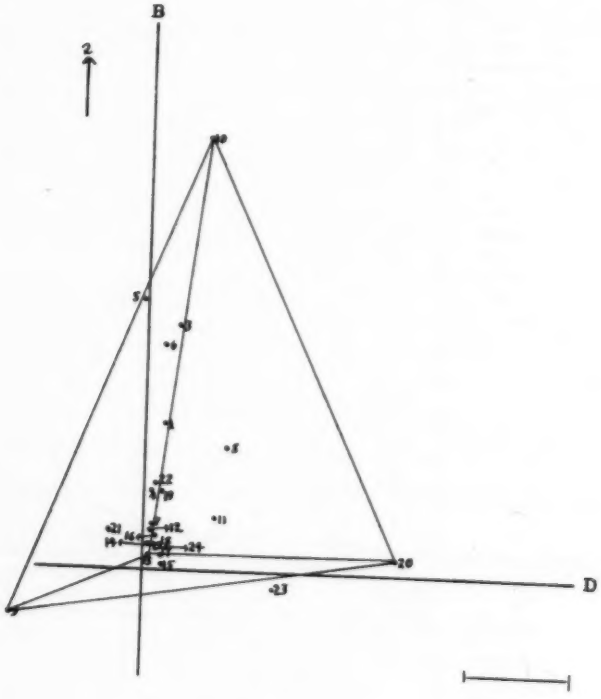


Figure 13

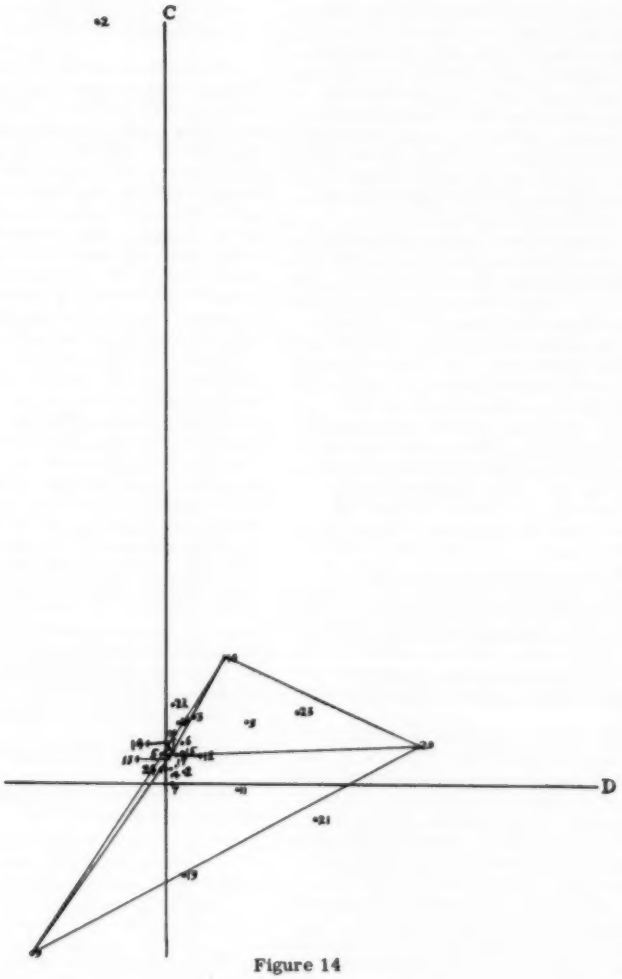


Figure 14

With the exception of A, Alientation, and (Y), Number of Yes-responses, this factor is made up of Mooney variables. This suggests that the Mooney Problem Check List actually does not serve as a basis for indicating different types of problems felt by college students, but that a student is governed by a response to any stated problem. The inclusion of (Y) in this set does not seem unreasonable for examination of the questions from which a (Y) score is built shows each question may be regarded as posing a problem not dissimilar from the Mooney problems. The first hypothesis that an affirmative response set exclusively underlies these loadings, however, cannot be accepted because other subtests of WSAI and the MMPI contain items similar to (A) and the Mooney variables, and yet, a problems response set is not manifest in them on this factor.

(Y) may be expected to have a loading on the same factor as (A) because the two are significantly correlated at the one percent level. The reason for this relationship may be found in the construction of the (A) score. Of 24 items in (A) calling for a Yes-No response, 21 items require Yes for a high score. In terms of points, 69 out of 83 points are accredited to a Yes-response to the items. Consequently, a high score in (A) of necessity must be accompanied by a high score in (Y). This relationship immediately suggests that the common factor is a Yes-response set. This hypothesis is not sustained, however, in view of the fact that a Yes-response tendency apparently did not force (WT) into this factor. Of 92 Yes-No items in (WT), 57 require a Yes for a high score. In corresponding points accredited to these responses, 183 out of 289 points are assigned to a high Yes score. A Yes-response tendency failed to produce in (WT) a factor pattern similar to that of (A) or (Y); therefore the hypothesis that this factor is exclusively a Yes-response factor is rejected.

This factor, (PRS), contributes to the variance of the practice teaching rating (PTR), but the factor (Int) apparently contributes to a greater degree. Although (PRS) contributes to both the Yes-response (Y) and (PTR), the assumption that a Yes-response set underlies the practice teaching rating to any substantial degree cannot be accepted, not only because of low loadings on this factor, but because (Y) seems to be an artifact of the test construction.

The hypothesis that an affirmative response set to any stated problem is the predominant characteristic of this factor was not sustained because the set failed to operate in variable (WT). The alternative hypothesis that this factor is characterized by a response set to problems actually felt by the student is accepted. Variable (MTS), indicating the total number of problems responded to by college students, supports this hypothesis on the basis of its high loading.

Common Factor: (PM) Professional Maturity

The variables having significant loadings on this factor are as follows:

8	(PGPA)	.54
9	(TGPA)	.31
11	(M)	.43
20	(Mf)	.48
23	(WPJE)	.47

(PGPA) is of complexity two, but its highest loading occurs on this factor. The interpretation of this factor is not difficult with the exception of the incongruity existing between (PGPA) and (TGPA). (TGPA) has been reflected twice so that now a high score is indicative of good grades. (PGPA) has been reflected only once and a high score indicates poor grades in education courses. This disparity in senses most likely was a consequence of fundamental differences between the professional experiences furnished to students in education courses and the experiences they acquired in courses outside of the professional education curriculum.

The four traits which may be considered as characterizing this factor are: youthfulness, undifferentiated interest pattern, poor professional educational judgment, and low grades in education courses. The traits cluster around a quality which seems to be essentially maturity as related to professional education. The findings suggest that feminine interest patterns are accentuated among older female students, among female students showing better professional judgment. Further investigation in this area is warranted. The masculinity-femininity interest pattern of an individual might prove to be a valuable clue in selecting, guiding, and counseling prospective teachers. This factor has been named "Professional Maturity" on the basis of considering the positive senses of the four characterizing traits.

Common Factor: (Int) Introversion

The variables having significant loadings on this factor are as follows:

18	(PTR)	.49
19	(Ma)	.37
21	(D)	.97
22	(IE)	.68

(PTR), the practice teaching rating, is of complexity two and (IE), Social Introversion-Extroversion, is of complexity four. These variables were included in the set because their loadings appear highest on this factor. (Ma), Hypomania, has been reflected so that a high score is indicative of the sense opposite to overactivity. Whether this sense may be taken to mean underactivity or not is difficult to say. It would seem that this interpretation may be made

because of its association with a state of depression.

The naming of this factor is quite speculative. Apparently, the three MMPI scales are measuring similar areas of personality rather than independent areas. Lack of teaching ability as measured by (PTR) agrees with the MMPI scales because teaching requires an extrovertive individual. Accordingly, the interpretation that this factor primarily is related to introversion may be accepted.

Common Factor: (SA) Social Adjustment

The variables having significant loadings on this factor are as follows:

2	(P)	.65
3	(S)	.46
5	(I)	.40
6	(WT)	.90
10	(BTAT)	.55

Excluding (C), Control, which has an insignificant communality and (A), Alienation, which appears on common factor (PRS), the loadings of this factor chiefly are peculiar to the WSAI. (BTAT), attitude toward teaching, is commensurate with attitudes towards life in general expressed by the WSAI variables. High scores are obtained by prospective teachers who lack purpose, a sympathetic attitude, sense of social membership, and who tend to be impulsive. That such individuals may countenance unfavorable attitudes towards teachers and the teaching profession is an outcome which may be expected. Therefore, this factor may be interpreted as Social Adjustment.

As in the case of the Mooney Problem Check List and the Minnesota Multiphasic Personality Inventory, the subparts of the WSAI are quite homogeneous in that, with one exception, they fail to separate factorially. Alienation is the only subtest, apparently, that measures a different aspect of personality.

Common Factor Conclusions

From the preceding results, it may be seen that four common factors definitely emerge. The intercorrelations of these factors (θ, Table A20) disclose that the association between a response set to felt problems is independent of a student's professional maturity, and may also be considered as quite unrelated to the degree of social adjustment. The negative relationship between the response factor and introversion indicates that a student who tends towards introversion is not inclined to admit problems. Professional maturity shows unrelatedness to introversion, but a negative correlation with social adjustment. This latter relationship is difficult to account for, but may be a result of the time interval during which the various tests were administered. The high correlation between the introversion factor and the social adjustment factor is a natural consequence of similarity in personality traits.

The size of the communality of a test may be taken as an index of discriminative power because it indicates the percent of the variance of the test accounted for by the common factors. When tests are of complexity one, this index becomes particularly useful for identifying tests which possess good discriminating value relative to single factors. The high communalities (See Table A20) of (WT) and (MTS) suggest that these composite measures have better discriminative value relative to factors (SA) and (PRS) than have the subtests which make up the composite measures. (D) and (IE) possess good analytical qualities with respect to factor (Int). This means that (WT), (MTS), (D), and (IE) will serve as better measuring instruments of their respective factors than the other tests used in this analysis.

Whether other common factors are present in the matrix of residual correlations is questionable. The criteria previously accepted indicated that further factorization seemed unwise, but the sizes of the residuals do not preclude additional common factors. Inasmuch as the results of the analysis provide answers to the questions originally asked, further factoring seemed unnecessary.

Conclusions

This analysis indicates that four common factors were resident in the table of intercorrelations observed between twenty-four measures investigated. These factors were named:

Problems Response Set	(PRS)
Professional Maturity	(PM)
Introversion	(Int)
Social Adjustment	(SA)

Orthogonality was not imposed on these factors and, accordingly, various degrees of relatedness exist between them. In general, the factors failed to cut across the personality areas measured by the Washburn Social Adjustment Inventory, Mooney Problem Check List, and the Minnesota Multiphasic Personality Inventory. This indicates that these instruments are measuring different aspects of personality. Substantial homogeneity was found among the subtests of each of the three instruments. The inference may be made that the subtests in any one instrument generally are measuring the same areas. Refinement of experimental design, however, may factorially separate the subtests.

It seems that professional grades are affected by a professional maturity factor and a soc-

ial adjustment factor, but the total grade point average is affected by the professional maturity factor only.

Attitude towards teachers and the teaching profession reflects a general social adjustment attitude. There was lack of sufficient evidence to indicate that a Yes-response set was related in any substantial degree to the practice teaching rating.

SECTION V

FACTOR ANALYSIS OF MALE SCORES

The intercorrelations of the male scores appear below the principal diagonal of Rm in Table B1 of Appendix B. Variables 8, 9, 10, and 11 were reflected prior to entry in R_M. The number of cases upon which the coefficients were based appear below the principal diagonal.

The development of a primary axes solution for the male scores was similar to the procedure used in factoring the female scores.

Adjusting communality estimates several times and reproducing the correlation matrix with two common factors produced residual correlations which were within sampling error of the original correlation. The distribution of the residual correlation had a mean -0.002 and standard deviation of 0.147. This compared not unfavorably with the distribution of a zero correlation for the number of cases involved. The fit of two common factors in this analysis was not as satisfactory as that in the female analysis, but the criteria had indicated that any factors beyond two would encroach into specific factor space.

Interpretation of the Male Factor Matrix

Two common factors which emerged from the male correlations were essentially orthogonal by virture of the negligible correlation between the ftwo factors. Consequently, the structure and pattern matrices were similar and interpretation could be made from either. The pattern values greater than 0.30 were rounded to two digits to the right of the decimal point and were expressed in the matrix P_M. (Table B2). Interpretation will be made from P_M.

Comparison of P_M with V_P of the female analysis shows a male factor pattern which is less decisive and commanding than that of the female pattern. The dissimilarity between the two solutions, for the most part, probably is a result of sex differences. However, the limited sizes of the samples in both analyses probably also operated in some indeterminable degree to cause disparate results.

Common Factor: (SEA) Social and Educational Adjustment

The variables having significant loadings on this factor are as follows:

2	(P)	.62
3	(S)	.50
6	(WT)	1.00
8	(PGPA)	.36
9	(TGPA)	.32
10	(BTAT)	.43
11	(PTR)	.33

(WT) manifests an impossible communality. As explained in Section IV, variables which are a composite of several other variables in a set frequently exhibit this property. In these cases it is best to consider the communality as slightly less than unity.

(P) Purpose, (S) Sympathy, and (WT) the Washburne subtotal are aligned with the educational measures. This indicates that a male student's purpose and general social adjustment are related factorially to his educational career. The factor has been anmed Social and Educational Adjustment.

Common Factor: (PPF) Personality-Psychological Factor

The variables which have significant loadings on this factor are as follows:

1	(C)	.63
4	(A)	.62
7	(Y)	.37
12	(FLE)	.44
13	(SRA)	.48
14	(SPR)	.85
15	(PPR)	.96
16	(ACW)	.53
17	(FVE)	.66
21	(D)	.30
22	(IE)	.42
24	(MTS)	.91

All variables on this factor except (Y) purportedly are measures of a personality or psychological nature. The inclusion of the Yes-response variable poses question whether all measures are a Yes-response set, or whether (Y) has a significant loading by virtue of the construction of the items of the WSAI. Insufficient evidence is available for a definite answer. It would seem that this factor actually is related to the personality and psychological traits of students and that the Yes-response set results from the preponderance of Yes-responses required to obtain a high score in (A) Alienation and (C) Control. As in (A), (C) requires

a larger number of Yes-responses than No-responses for a high score. This compels (Y) to have a factor pattern similar to (A) and (C), thereby negating the plausibility of the factor being exclusively a Yes-response set factor.

This factor has been called "Personality-Psychological Factor."

Conclusions

Two orthogonal common factors emerged from the matrix of intercorrelations of the male scores. It may be concluded that female and male students differ factorially relative to the instruments used in this study. The Mooney Problem Check List variables, the Minnesota Multiphasic Personality Inventory Scales and (C) and (A) of the Washburne Social Adjustment Inventory measure the same personality dimension of the male students. A male student's adjustment in purpose and sympathy apparently lie in the same area of personality as various educational instruments such as grades, attitudes toward teachers and the teaching profession, and practice teaching ability. This implies that a male student who gets good grades in education as well as in general courses is likely to exhibit good teaching skill and possess a favorable attitude towards teaching as a career.

On the basis of the size of the communality, the number of problems to which a male student responds in the area Personality-Psychological Relations of the Mooney Problem Check List serves as the best discriminating measure of the factor (PPF). The Washburne subtotal score (WT) is the best measure of the second factor, (SEA).

SECTION VI

SUMMARY

Statement of the Problem

The purpose of this investigation was to determine with factor analysis if a few common factors might adequately summarize areas of personality, achievement, and abilities of prospective teachers frequently measured by educational and psychological instruments. Complementary to this general objective, the factorial nature of parts of the measuring instruments were to be analyzed relative to female and male student differences.

Measures Used in the Analyses

Twenty-four variables were used in these analyses. Seven variables were derived from the Washburne Social Adjustment Inventory; seven were derived from the Mooney Problem Check List; and four scales of the Minnesota Multiphasic Personality Inventory were used. The remaining six variables were personal data measures obtained from the student files.

Procedure of the Analyses

Numerical descriptions of the twenty-four traits of 51 female students and 51 male students in the School of Education were intercorrelated. Each correlation matrix was factored by the multiple group method. The determination of the number of common factors was based on three criteria: examination of a geometrical projection of the traits configuration, an inverse matrix test, and the size of the residual correlations.

The initially obtained oblique structures were rotated directly to primary structures. Interpretation was made from the primary structure in the female analysis and from the primary pattern in the male analysis.

Common Factors Found in the Female Analysis

Four oblique common factors were found to encompass the intercorrelations of traits of the female group. The common factors and the traits having loadings acceptable for interpreting the nature of the factors were found to be:

I Problems Response Set: Alienation; Yes-response; Problems in Finances, Living Conditions, and Employment; Problems in Social and Recreational Activities; Problems in Social-Psychological Relations; Problems in Personal-Psychological Relations; Problems in Adjustment to College Work; Problems concerning the future—Vocational and Educational; Total Number of Problems.

II Professional Maturity: Professional Grade Point Average; Total Grade Point Average; Age; Masculinity-Femininity Interest; Wright Professional Judgment Examination.

III Introversion: Practice Teaching Rating; Hypomania; Depression; Social Introversion-Extroversion.

IV Social Adjustment: Purpose; Sympathy; Impulse-Judgment; Washburne Subtotal; Best's Teacher Attitude Test.

Using the size of the communality as a criterion for identifying measuring instruments having high discriminative value, the total number of problems to which female students respond on the Mooney Problem Check List proved to be the best single test for discriminating in-

dividual differences relative to the problems response set factor. No really good measure of the professional maturity factor developed. The Depression scale of the Minnesota Multiphasic Personality Inventory was the best measure of the introversion factor. The Washburne subtotal score was found to be the best discriminating measure of the social adjustment factor.

The correlation between factors I and III indicates that an introvertive student does not respond as readily to stated problems as a student who is more extrovertive. Time lapse of administration of tests may account for the negative relationship appear between factors II and IV. The strong positive relationship between factors III and IV indicates an underlying second order factor probably of a psychological nature.

Common Factors Found in the Male Analysis

Two orthogonal common factors emerged from the intercorrelations of traits of the male students. Interpretation was less conclusive than interpretation made from the female analysis.

The common factors and the traits having loadings acceptable for interpreting these factors were found to be:

I Social and Educational Adjustment: Purpose; Sympathy; Washburne Subtotal; Professional Grade Point Average; Total Grade Point Average; Best's Teacher Attitude Test; Practice Teaching Rating.

II Personality-Psychological Factor: Control; Alienation; Yes-response; Problems in Finances, Living Conditions, and Employment; Problems in Social Recreational Activities; Problems in Social-Psychological Relations; Problems in Personal-Psychological Relations; Problems in Adjustment to College Work; Problems concerning the future—Vocational and Educational; Depression; Social Introversion-Extroversion; Total Problems (Mooney).

The Washburne subtotal score possessed the greatest discriminative value for measuring the social and educational factor; and the Personal-Psychological Relations section of the Mooney Problem Check List provided the best measure of the personality-psychological factor.

Conclusions

Relative to the female students in this study, the Washburne Social Adjustment Inventory, Mooney Problem Check List, and certain scales of the Minnesota Multiphasic Personality Inventory, in general, do not measure the same personality dimensions. A professional maturity factor relates the grades and professional teaching judgment of female students with age and interest patterns characteristic of women. A female student who is introvertive and depressed will tend to exhibit poor teaching skill as rated by an experienced teaching critic. Female students reflect the same attitudes towards teachers and the teaching profession as they have towards society in general.

The factor pattern of the male students shows a marked discrepancy from that of the female students. Less decisive interpretations can be made from the male analysis. The Mooney Problem Check List and certain scales of the Minnesota Multiphasic Personality Inventory failed to separate on different factors. The education measures seem to be related with a male student's sense of sympathy and purpose in life, whereas none of the education measures seem related to the tendency to respond to stated problems or abnormal psychological traits.

In these analyses, a Yes-response set, and consequently the tendency towards the quality of being a "yes-man", was not found to underlie to any substantial degree either good grades or favorable practice teaching ratings.

BIBLIOGRAPHY

1. Blum, Lawrence P. "A Comparative Study of Students Preparing for Five Selected Professions Including Teaching," Journal of Experimental Education, XVI (September 1947), 31-65.

2. Coombs, C. H. "A Criterion for Significant Common Factor Variance," Psychometrika, VI (August 1941), 267-72

3. Drake, L. E. "A Social I.E. Scale for the Minnesota Multiphasic Personality Inventory," Journal of Applied Psychology, XXX (February 1946), 51-54.

4. _____, and Thiede, W. "Further Validation of the Social I. E. Scale for the Minnesota Multiphasic Personality Inventory," Journal of Educational Research, XLI (March 1948), 551-6.

5. Garrett, Henry E. Statistics in Psychology and Education (New York: Longmans, Green and Co., 1947). Pp. xii+487.

6. Guttman, Louis. "General Theory and Methods for Matric Factoring," Psychometrika, IX (March 1944), 1-16.

7. Harris, Chester W. "Direct Rotation to Primary Structure," Journal of Educational Psychology, XXXIX (December 1948), 449-68.

8. _____, "Projections of Three Types of Factor Patterns," Journal of Experimental Education, XVII (March 1949), 335-46.

9. _____, and Knoell, Dorothy M. "The Oblique Solution in Factor Analysis," Journal of Educational Psychology, XXXIX (November 1948), 385-403.

10. _____, and Schmid, John Jr. "Some Further Applications of Principles of Direct Rotation to Primary Structure," Journal of Experimental Education, XVIII (March 1950), 175-194.

11. Harsh, Charles M. "Constancy and Variation in Patterns of Factor Loadings," Journal of Educational Psychology, XXXI (May 1940), 335-59.

12. Hathaway, S. R., and McKinley, J. C. "A Multiphasic Personality Schedule: I. Construction of the Schedule," Journal of Psychology, X (1940), 249-54.

13. Holzinger, Karl J. "A Simple Method of Factor Analysis," Psychometrika, IX (December 1944), 257-62.

14. _____, and Harman, Harry H. Factor Analysis (Chicago: University of Chicago Press, 1948). Pp. xii+417.

15. _____, and Swineford, Frances. A Study in Factor Analysis: The Stability of a Bi-factor Solution. Supplementary Educational Monographs, No. 48 (Chicago: Department of Education, University of Chicago, 1939).

16. Horst, P., and others. The Prediction of Personal Adjustment (New York: Social Science Research Council, 1941). Pp. xii +455.

17. Lough, O. M. "Teachers College Students and the Minnesota Multiphasic Personality Inventory," Journal of Applied Psychology, XXX (June 1946), 241.

18. McNemar, Q. "On the Number of Factors," Psychometrika, VII (March 1942), 9-18.

19. Marzolf, Stanley S., and Larsen, Arthur Hoff. "Statistical Interpretation of Symptoms Illustrated with a Factor Analyses Problem Checklist Items," Educational and Psychological Measurement, V (1945), 285-94.

20. Medland, F. F. "An Empirical Comparison of Methods of Communality Estimation," Psychometrika, XII (June 1947), 101-10.

21. Meehl, P. E., and Hathaway, S. R. "The K Factor as a Suppressor Variable in the Minnesota Multiphasic Personality Inventory." Journal of Applied Psychology, XXX (1946), 525-64.

22. Swineford, Frances. "Comparisons of the Multiple-factor and Bi-factor Methods of Analysis," Psychometrika, VI (December 1941), 375-82.

23. Thomson, Godfrey H. The Factorial Analysis of Human Ability (Chicago: Houghton Mifflin Co., 1948). Pp. xvi+392.

24. Thurstone, L. L. Primary Mental Abilities. Psychometric Monographs, No. 1 (Chicago: University of Chicago Press, 1938). Pp. 121.

25. _____, "A Multiple Group Method of Factoring the Correlation Matrix," Psychometrika, X (June 1945), 73-8.

26. _____, Multiple-Factor Analysis (Chicago: University of Chicago Press, 1947). Pp. xiv+535.

27. _____, "Note About the Multiple Group Method," Psychometrika, XIV (March 1929), 43-5.

A STUDY OF LATERALITY CHARACTERISTICS OF RETARDED READERS AND READING ACHIEVERS

LINDA C. SMITH
Temple University
Philadelphia, Pennsylvania

THE PROBLEM AND ITS SCOPE

This investigation is an attempt to determine to what degree laterality test findings can be used to differentiate between retarded readers and reading achievers. For this study, data were obtained on each of the following questions:

1. Do parents of retarded readers differ from parents of reading achievers in regard to hand preference?
2. Do the developmental histories reveal differences between retarded readers and reading achievers in regard to change of hand preference?
3. To what extent do retarded readers and reading achievers differ in hand preference as evidenced by:
   a. strength?
   b. dexterity?
4. To what extent do retarded readers and reading achievers differ in foot preference as evidenced by kicking?
5. To what extent do retarded readers and reading achievers differ in eye preference as evidenced by:
   a. sighting at distance?
   b. convergence at near point?
   c. acuity of vision at far point?
   d. acuity of vision at near point?
6. To what extent do retarded readers and reading achievers differ in ear preference as evidenced by:
   a. choice of ear in listening?
   b. acuity of hearing?
7. To what extent do retarded readers differ from reading achievers in regard to combinations of hand and eye preference?
8. To what extent do retarded readers differ from reading achievers in the performance of mirror drawing?
9. To what extent do retarded readers and reading achievers differ in reversal tendencies as evidenced by:
   a. copying lower case letters?
   b. reading lower case letters?
10. Do the findings from the Van Riper test of "Central" Dominance (61) differentiate between retarded readers and reading achievers?

Justification of the Study

The justification of this study is threefold. First, there is a need for data on the relationship between indices to laterality and lack of achievement in reading. Second, the findings of this study should have value for the classroom teacher who deals with the causes of reading deficiencies. Third, this study should have implications concerning the use and interpretation of certain laterality tests in clinical situations.

Limitations of the Study

Experimental Design. This study is a survey of two groups from the same population. They were matched on the basis of chronological age and intelligence quotient, and differed in respect to reading quotient. The intelligence quotient was determined by means of the 1937 Revision of the Stanford-Binet Test of Intelligence[1]; the reading quotient, by the Alice Horn formula (27):

$$\text{R. Q.} = \frac{\text{R. A.}}{(2\ \text{M. A.} + \text{C. A.}) + 3}$$

The Population. One hundred subjects were used.

1. Sex. Only white males were used in this study.
2. Age. The chronological age range was from 9 to 11 years, inclusive.
3. Intelligence. The intelligence quotient range for retarded readers was from 90 to 131; for reading achievers, from 90 to 125.
4. Reading Quotient. The reading quotients of the retarded readers ranged from 69 to 88; of the reading achievers, from 100 to 120.
5. School Experiences. The cases selected for the study were obtained from Grades Three to Five, inclusive. Previous school exper-

1. Published by Houghton Mifflin Co., Boston, Mass.

iences met three criteria:

a. Instruction had been given in typical classroom situations.
b. Classroom enrollment had not exceeded fifty.
c. School attendance had been regular.

6. Language Background. Only children from English speaking homes were considered in this study.
7. Geographical Area. The subjects were selected from Camden, New Jersey, and Philadelphia and its suburbs. They represented six parochial schools and twenty-one public schools.

Laterality Tests. In addition to pupil and parent interviews, twenty-seven tests were given and the scores recorded. Certain observations of test performance were made.

1. Peripheral Dominance
   a. Eleven tests of hand preference
   b. Two tests of foot preference
   c. Eight tests of eye preference
   d. Two tests of ear preference
2. Mirror Drawing
3. Two tests of reversals
4. The Van Riper Test of "Central" Dominance

Statistical Procedures. Small sampling analysis techniques were employed throughout this study. Fisher's t was used for matching the two groups in this study. Chi square was used on results of laterality tests. When the observed difference was found to be significant at the one percent level, tetrachoric r was used to substantiate the finding.

Terminology

Retarded Readers. For the purpose of this study a retarded reader is one who:

1. Achieved a score of less than 50 percent on an isolated word recognition test for grade one.
2. Achieved a comprehension score of less than 60 percent on a reading selection for grade one.
3. Achieved a score of 70 percent or better on an informal hearing comprehension test for his instructional grade.

Reading Achievers. A reading achiever is herein regarded as one who has a reading quotient of 100 or above as determined by the Alice Horn formula (27).

REVIEW OF KINDRED LITERATURE

Conflicting concepts have long obtained concerning the possible relationship between cerebral dominance and laterality of function. The association of these two factors is not yet adequately understood.

Peripheral Dominance

1. Hand preference was recognized as early as 1100 B.C. (30).
2. Handedness has been classified as being either native or acquired. The possible conditions of hand preference are right and left handedness and ambidexterity (46).
3. No proof has been established to show that inheritance does not affect dominance. It is probable that a combination of inheritance and of social influences determines the laterality characteristics of each individual (46).
4. Hand preference has been given a major portion of attention in the literature.
   a. Left handedness predominates in some families (5). Whether this is due to inheritance, or to association with left handed members of the family, remains undetermined.
   b. It is generally conceded that about six percent of the population are left handed. However, the reports on this factor vary from two percent to forty percent (1, 5, 7, 31).
   c. Forced change of handedness may be accompanied by (1) mirror writing and reversals, (2) disturbance of emissive language, (3) fatigue, or (4) emotional disturbance (5, 21, 41, 56).
   d. Hand preference first appears toward the end of the first year of infancy (19). Marked increase of preference occurs at periods when the finer muscles are being trained, as in writing (36).
   e. There appears to be some correlation between intelligence and degree of hand preference, more ambidexterity being found among the backward and feebleminded (5, 37).
   f. Conflicting evidence obtains as to whether girls and boys differ in regard to hand preference (5, 15, 36, 38, 56).
   g. The possibility that left hand preference may be a result of emotionality has been suggested (2). The weight of evidence points, rather, to emotional disturbance as an indirect result of left handedness (5, 21, 35).
   h. Evidence of possible relationship between handedness and language function has been advanced (5, 21, 35).
      (1) A developmental relationship between speech and lateral dominance is suggested by the fact that they begin to develop coincidentally (36).
      (2) There is much evidence of a lack

of association between reading and hand preference (13, 18, 22, 64, 66). However, more ambidexterity has been found among retarded readers than among good readers (11, 40).

(3) There appears to be a causal relationship between gain in facility in writing and decrease in ambidexterity (5, 57).

(4) The controversy concerning the possible relationship between speech disturbance and conditions of dominance is unsettled (36).

(a) Stuttering has been observed to develop during the periods which mark the greatest development of hand preference: from two to three years and at about the sixth year (45).

(b) That speech is not affected by conditions of handedness is maintained by certain investigators (5, 46).

(c) Another assertion is that among mixed handedness groups, and where laterality of eye and hand are crossed, more speech defects are found (43).

(d) Emotionality caused by disturbance of natural hand preference may, in turn, cause difficulty with speech emission (5, 21).

(e) Precautions should be taken against emotional strain if change of handedness is undertaken (21).

5. Man usually has a preferred foot (29). Tests of foot preference have frequently been included in batteries of laterality tests (15, 22, 50). The significance of foot preference has not been extensively treated. Its interpretation has been found difficult (50).

6. Eye dominance as a single factor does not exist. Several factors of eye preference have been studied (62).

a. In the sixteenth century, the Porta staff was devised to test the sighting eye (7).

b. The eye which is dominant for sighting is not always dominant in other respects (34, 62).

c. Monocular preference varies with distanceof fixation (31).

d. Claims have been made that there is correspondence of function between eye and hand (28). It has been asserted that this relationship is a causative one (9, 20, 46). This theory has, however, been questioned and evidence offered against its acceptance (33, 51).

e. Eye preference and intelligence have been found to be unrelated (6).

f. For many, ocular dominance is not established until the third year (58). Monocular tendencies increase with age (7, 51).

g. Retarded readers have been reported to evidence a predominance of left eye preference and of mixed ocular dominance (11). In conflict with this report, however, evidence has been offered of a lack of relationship between ocular dominance or mixed hand-eye dominance and reading achievement (13, 18, 64, 66).

h. A difference in space sense between the two halves of the retina has been reported (7, 54). It has been suggested that handedness may result from this inequality of space sense (54).

i. Superior readers have been found to excel defective readers in perception in the left visual field (8).

j. Attempts have been made to determine whether there is a relationship between hand preference and preferential position for attention getting within the visual field (4, 14).

k. There is a tendency to minimize eye preference as a factor related to reading achievement (16).

7. Hearing acuity seems unrelated to hand preference, while the ear used for listening seems to correspond with the preferred hand (31).

Veering

Veering appears to be more closely associated with structural dominance than with laterality of function as evidenced by hand and eye preference (32).

Mirror Drawing and Reversals

1. Mirror drawing has some value as a test of emotional stability (47).

2. Several viewpoints concerning reversals are expressed in the literature.

a. It has been claimed that the tendency to make reversals is associated with ambidexterity, left eye preference, change of hand or eye preference, and with mixed hand and eye preference (11, 12). It has also been claimed that there are no more reversals among children with mixed dominance than among other children (17, 39).

b. Dominance does not seem related to degree of reversal tendencies (17).

c. It has been reported that left handed children evidence a preference for right-left direction (42).

d. Ability in mirror reading and tendency toward making reversals are found to be more prevalent among retarded readers than among good readers (11, 44).
e. Confusion of identical elements and transfer of elements within a complex series have been suggested as causes of what appear to be reversals (48).
f. Evidence has been offered that reversals are largely a matter of stages of development (10, 24, 55, 65).

Theories of "Central" Dominance

The following theories concerning "central" dominance have been successively asserted since the early nineteenth century.

1. Some relationship exists between cerebral lesions and retention of function (23).
2. The crossing of the pyramids, or bundles of motor nerves, accounts for retention of function on the opposite side to the lesion (23).
3. The left hemisphere controls speech (63).
4. Automatic speech responses are represented in both hemispheres (63).
5. The memory center for letters and words is in the same hemisphere as the motor center for speech and writing (25).
6. Aphasic disorders may be classified as (1) verbal, (2) syntactical, (3) nominal, and (4) semantic (23).
7. Both hemispheres are active in many speech performances (63).
8. Man can be left brained for hand skills and right brained for speech skills (63).
9. Speech functions employ the unified activity of many cerebral areas (63).
10. Localization of brain destruction is more important than amount of tissue destroyed (45).
11. One cerebral hemisphere controls speech and manual dexterity while the other hemisphere is useless or unused (45).
12. Specialized control is found only in language faculty and in intricate manual skills (45).
13. Peripheral retinal fields are organized as crossed but independent mechanisms (45).
14. There are three levels of complexity with which the brain makes use of incoming data (45).
    a. Cortical blindness or cortical deafness can result from bilateral injury to appropriate areas controlling the first level (45).
    b. Mind blindness or mind deafness can result from injury to appropriate areas, in both hemispheres, controlling the second level (45).
    c. Word deafness or word blindness can be caused by injury to appropriate areas in only one hemisphere (45).
15. Laterality becomes more pronounced as encephalization of function takes place (3).
16. Some people form engrams almost equally well in either cerebral hemisphere (41).
17. Eleven subdivisions of the cerebral hemisphere comprise the functional area for association. These subdivisions are in pairs. The degree to which laterality has been developed varies from pair to pair. The extent and degree of dominance also varies with the individual (41).

Van Riper Test of "Central" Dominance

The Van Riper critical angle board was devised as a test of laterality. Patterns were drawn bimanually on opposite sides of a vertical form board at various angles. This test served to distinguish between children who were ambidextrous and those who evidenced distinct hand preference. Van Riper assumed that asymmetry of function as demonstrated by performance on the critical angle board was the result of asymmetrical functioning of the cerebral hemispheres. He did not, however, attempt to interpret his test findings in terms of neurological conditions represented thereby (59, 60, 61).

SUMMARY OF RESULTS

1. There was no significant difference between the hand preference of parents of retarded readers and the hand preference of parents of reading achievers as reported in interviews. Left hand preference was claimed for 11 percent of the parents of retarded readers, and for 10 percent of the parents of reading achievers.
2. Change of handedness had been experienced by more retarded readers than reading achievers. Change to use of the right hand was reported by 12 percent of the retarded readers and by 4 percent of the reading achievers. No changes from right to left hand were reported. The numbers of cases in some categories were so minute that chi square was not used.
3. The tests of hand preference did not differentiate between retarded readers and reading achievers.
    a. When strength of grip was used as a criterion, there was no significant difference between retarded readers and reading achievers. Right hand preference was evidenced by 92 percent of the retarded readers and by 90 percent of the reading achievers; left hand preference, by 8 percent of the retarded readers and by 6 percent of the reading achievers.
    b. On the basis of dexterity, no significant difference was found between retarded readers and reading achiev-

ers. In no case was the difference found to be significant at the 1 percent level.

c. On the basis of eleven tests of hand preference, the classification of retarded readers was: 92 percent right; 8 percent left. The reading achievers were classified as 86 percent right; 14 percent left. This difference is not statistically significant.

4. On the basis of two tests of kicking, no statistically significant difference was found between retarded readers and reading achievers in foot preference. The classification of the retarded readers was found to be 80 percent right, 8 percent left, 12 percent ambi; of reading achievers, 78 percent right, 8 percent left, and 14 percent ambi.

5. On the basis of eight tests, including four types of tests used to measure eye preference, no significant difference was found between retarded readers and reading achievers.

a. On the basis of each of five sighting tests, the difference between retarded readers and reading achievers was too small to be significant. On the basis of all five sighting tests, the classification of the retarded readers was 58 percent right and 42 percent left; of the reading achievers, 66 percent right and 34 percent left. This difference is not statistically significant.

b. On the basis of the test of near point of convergence, no significant difference was found between retarded readers and reading achievers. The eye preference of retarded readers was found to be 60 percent right and 40 percent left; of reading achievers, 62 percent right and 38 percent left. This difference is not statistically significant.

c. On the basis of visual acuity at far point, no significant difference in eye preference was found between retarded readers and reading achievers. The classification of retarded readers for eye preference on this basis was 12 percent right, 18 percent left, and 70 percent ambi. For reading achievers, the classification was 20 percent right, 20 percent left, and 60 percent ambi. This difference is not statistically significant. However, a much greater loss of visual acuity at far point was present among reading achievers than among retarded readers. This was true for both left and right eyes.

d. There was no significant difference between retarded readers and reading achievers on the basis of the test of visual acuity at near point. Based on this test, the classification of retarded readers as to eye preference was 4 percent right, 12 percent left, and 84 percent ambi; of reading achievers, 14 percent right, 8 percent left, and 78 percent ambi. This difference is not statistically significant.

6. On the basis of two tests of ear preference, no significant difference was found between retarded readers and reading achievers.

a. On the basis of the ear used in listening, the classification of retarded readers was 46 percent right and 54 percent left. The classification of reading achievers was 64 percent right and 36 percent left. This difference is not statistically significant.

b. On the basis of auditory acuity findings, no significant difference in laterality was found between retarded readers and reading achievers. The ear preference of retarded readers was found to be 30 percent right, 40 percent left, and 30 percent ambi; of reading achievers, 12 percent right, 22 percent left, and 66 percent ambi. This difference is not statistically significant. The average hearing loss of retarded readers was greater for both left and right ears than was that of reading achievers.

7. On the basis of all the tests of hand preference and eye preference given, very small differences were found between retarded readers and reading achievers.

a. Right eye and right hand preference were evidenced by 54 percent of the retarded readers and by 58 percent of reading achievers.

b. Left eye and left hand preference were evidenced by 2 percent of the retarded readers and by 6 percent of the reading achievers.

c. Right eye and left hand preference were evidenced by 6 percent of the retarded readers and 8 percent of the reading achievers.

d. Left eye and right hand preference were evidenced by 34 percent of retarded readers and 24 percent of reading achievers.

e. Ambi eye and right hand preference were evidenced by 4 percent of the retarded readers and by 4 percent of the reading achievers.

The frequencies in several of the categories were too small to admit of the use of chi square on the findings concerning combinations of hand preference and eye preference.

8. On the basis of mirror drawing findings, no significant difference was found between retarded readers and reading achievers. Of the retarded readers, 36 percent reproduced the mirror pattern faster with the right hand; 64 percent, with the left. Of the reading achievers, 28 percent performed faster with the right hand; 72 percent, with the left. This difference is not statistically significant. In accuracy of mirror drawing, the classification of retarded readers and reading achievers was identical: 48 percent right, 50 percent left, and 2 percent ambi.

9. On the basis of reversals, a significant difference was found between retarded readers and reading achievers.

a. Very few reversals were made in copying letters. For that reason, the results of this test were considered negligible.

b. On the basis of reading lower case letters, a significant difference was found between retarded readers and reading achievers. Some reversals were made by 86 percent of the retarded readers; no reversals, by 14 percent. Of the reading achievers 22 percent made some reversals; 78 percent, no reversals. This difference is statistically significant.

10. On the basis of the Van Riper Test of "Central" Dominance, a significant difference was found between retarded readers and reading achievers.

a. When each individual was classified according to the hand more frequently used for reversal at the critical angle, the difference between retarded readers and reading achievers was very small. The classification of retarded readers was 68 percent left, 26 percent right, and 6 percent ambi; of reading achievers, 76 percent left, 22 percent right, and 2 percent ambi. The frequencies in some categories were too small to admit of the use of chi square.

b. On the basis of cumulative frequencies of reversals with each hand at the critical angle, the difference between retarded readers and reading achievers was found to be significant at the 2 percent level.

c. On the basis of cumulative frequencies of reversals with each hand at the critical angle for each of four types of patterns separately, no significant differences was found between retarded readers and reading achievers. The types of patterns were tactile-kinaesthetic, kinaesthetic-kinaesthetic, auditory-kinaesthetic, and visual-kinaesthetic.

d. No statistically significant difference was found between retarded readers and reading achievers as to the hand used for reversal at the critical angle when that angle was 180, 240, or 300 degrees. At the critical angle of 360 degrees, the retarded readers reversed 114 times with the right hand and 84 times with the left; the reading achievers, 83 times with the right hand and 120 times with the left. This difference is significant at the one percent level.

CONCLUSIONS

Within the limitations of this study, the following conclusions appear to be valid:

1. Parents of retarded readers do not differ significantly from parents of reading achievers in regard to hand preference.

2. Retarded readers and reading achievers do not differ significantly in regard to the incidence of change of handedness.

3. Retarded readers and reading achievers do not differ significantly in regard to hand preference.

4. Retarded readers and reading achievers do not differ significantly in regard to foot preference.

5. Retarded readers and reading achievers do not differ significantly in regard to eye preference.

6. Retarded readers and reading achievers do not differ significantly in regard to ear preference.

7. Retarded readers and reading achievers do not differ significantly in regard to combinations of hand and eye preference.

8. Retarded readers and reading achievers do not differ significantly in regard to the hands used more successfully in terms of speed or accuracy in mirror drawing.

9. Retarded readers make significantly more reversals than reading achievers in reading lower case letters.

10. Retarded readers and reading achievers differ significantly in their performance on the Van Riper Test of "Central" Dominance at the critical angle of 360 degrees. At this angle, the retarded readers reverse more often with the right hand; the reading achievers, with the left.

IMPLICATIONS FOR PRESENT PRACTICE

This study appears to have certain implications for teachers and clinicians who are working in the field of reading.

1. Handedness of parents need not be interpreted as a factor closely related to reading

retardation.

2. Change of handedness as a factor in developmental history may warrant consideration in the diagnosis of reading disability cases. However, this study does not show sufficient evidence to establish the importance of this factor.

3. Hand preference, except as related to change of handedness, is not an important factor in the diagnosis of reading disability cases.

4. Foot preference is not an important factor in the diagnosis of reading disability cases.

5. Eye preference is not an important factor in the diagnosis of reading disability cases. The weight of emphasis should be placed upon visual acuity findings at near point and at far point.

6. Ear preference for listening is not an important factor in the diagnosis of reading disability cases. Emphasis should be placed upon auditory acuity findings.

7. Combinations of eye and hand dominance are not important factors in the diagnosis of reading disability cases.

8. Mirror drawing may be useful as an index of emotional stability. However, as a test of hand preference, it does not contribute to the diagnosis of reading disability cases.

9. While reversals serve to differentiate between retarded readers and reading achievers, they probably should not be interpreted in terms of "central" or peripheral dominance.

10. The Van Riper Test of "Central" Dominance may be useful in clinical practice since it does distinguish between retarded readers and reading achievers. It would seem advisable to limit its use to the 360 degree angle. Such limitation would be desirable from the standpoint of economy of time. To limit the use of the test to patterns of the auditory-kinaesthetic and visual-kinaesthetic types would give adequate data and would conserve the nervous energy of the subject.

IMPLICATIONS FOR FURTHER STUDY

1. More studies are needed to determine the relationships between change of handedness and written language facility.

2. The elusive problem of the meaning of reversals at the 360 degree angle on the Van Riper Test needs further study. Also, further research could establish the type of pattern which serves best to differentiate between retarded readers and reading achievers when this test is used. The psychoneurological implications of this finding are in need of careful analysis.

BIBLIOGRAPHY

1. Betts, Emmett A. Prevention and Correction of Reading Difficulties (Evanston, Illinois: Row, Peterson and Co., 1936).

2. Blau, Abram. The Master Hand, Research Monographs, No. 5 (New York: American Orthopsychiatric Association, Inc., 1946).

3. Brock, Samuel. The Basis of Clinical Neurology (Baltimore: Williams and Wilkins Co., 1945).

4. Burke, Ruth S. and Dallenbach, Karl N. "Position vs. Intensity as a Determinant of Attention of Left-Handed Observers," American Journal of Psychology, XXXV (April 1924), pp. 267-69.

5. Burt, Cyrill. The Backward Child (New York: D. Appleton Co., 1937).

6. Crider, Blake. "Minor Studies in Eye Preference," Child Development, VIII (December 1937), pp. 365-67.

7. _____. Ocular Dominance: Its Nature, Measurement and Development. Doctor's Dissertation, Western Reserve University, Cleveland, Ohio, 1934.

8. Crossland, H. R. "Superior Elementary-School Readers Contrasted with Inferior Readers in Letter-Position, 'Range of Attention', Scores," Journal of Educational Research, XXXII (February 1939), pp. 410-27.

9. Cuff, N. B. "Study of Eyedness and Handedness," Journal of Experimental Psychology, XIV (April, 1931), pp. 164-75.

10. Davidson, Helen Pye. "A Study of Confusing Letters, b, d, p, and q," Pedagogical Seminary and Journal of Genetic Psychology, XLVII (December 1935), pp. 458-68.

11. Dearborn, Walter F. "Ocular and Manual Dominance in Dyslexia," Psychological Bulletin, XXVIII (November 1931), p. 704.

12. _____. "Teaching Reading to Non-Readers," Elementary School Journal, XXX (December 1929), pp. 266-69.

13. Fernald, Grace M. Remedial Techniques in Basic School Subjects (New York: McGraw-Hill Book Co., 1943).

14. Fisher, M. Bruce, and Birren, James E. "Age and Hand Strength," The American Psychologist, II (October 1947), pp. 411-12.

15. Gast, Ira M. "A Study of Handedness," Journal of Educational Sociology, II (April 1929), pp. 487-91.

16. Gates, Arthur I. The Improvement of Reading. Third Edition (New York: Macmillan Co., 1947).

17. _____, and Bennett, Chester C. Reversal Tendencies in Reading (New York: Bureau of Publications, Teachers College, Columbia University, 1933).

18. _____, and Bond, Guy L. "Relation of Handedness, Eye-Sighting and Acuity Dominance to Reading," Journal of Educational Psychology, XXVII (September 1936), pp. 450-56.

19. Gesell, Arnold. "The Ontogenesis of Infant Behavior," Chapter 6 in Leonard Carmichael, Manual of Child Psychology (New York: John Wiley and Sons, 1946).

20. Gould, G. M. Righthandedness and Lefthandedness (New York: J. P. Lippincott Co., 1908).

21. Granich, Louis. Aphasia: A Guide to Retraining (New York: Grune and Stratton, 1947).

22. Haefner, Ralph. The Educational Significance of Left-handedness. Teachers College Contribution to Education, No. 360 (New York: Bureau of Publications, Teachers College, Columbia University, 1929).

23. Head, Henry. Aphasia and Kindred Disorders of Speech, Vol. I (Cambridge, England: University Press, 1926).

24. Hildreth, Gertrude. "Bilateral Manual Performance, Eye Dominance and Reading Achievement," Child Development, XI (December 1940), pp. 311-17.

25. Hinshelwood, James. Congenital Word-Blindness (London: H. K. Lewis and Co., Ltd., 1917).

26. Hollingsworth, Henry L. Mental Growth and Decline (New York: D. Appleton Co., 1927).

27. Horn, Alice McAnulty. Uneven Distribution of the Effects of Specific Factors, Southern California Education Monographs, No. 12 (Los Angeles: University of Southern California Press, 1941).

28. Humphrey, G. M. The Human Hand and the Human Foot (Cambridge, England: Macmillan Co., 1861).

29. Jastrow, J. "Dextrality," Baldwin's Dictionary of Philosophy and Psychology, Vol. I (New York: Macmillan Co., 1901), p. 227.

30. "Judges", The New Analytical Bible and Dictionary of the Bible, XX. Authorized Version (Chicago: John A. Dickerson Publishing Co., 1938), pp. 15-16.

31. Koch, Helen Lois. "A Study of the Nature, Measurement, and Determination of Hand Preference," Genetic Psychology Monographs, XIII (February 1933), pp. 112-221.

32. Lund, Frederick H. "The Dependence of Eye-Hand Coordination Upon Eye-Dominance," American Journal of Psychology, XLIV (October 1932), pp. 756-62.

33. Lynn, George W. Handedness in the Blind. Master's Thesis, Temple University, Philadelphia, 1932.

34. Marlow, F. W. The Relative Position of Rest of the Eyes and the Prolonged Occlusion Test (Philadelphia: F. A. Davis Co., 1924).

35. McCallister, James M. "Character and Causes of Retardation in Reading Among Pupils of the Seventh and Eighth Grades," Elementary School Journal, XXXI (September 1930), pp. 35-43.

36. McCarthy, Dorothea. "Language Development in Children," Chapter 10 in Leonard Carmichael, Manual of Child Psychology (New York: John Wiley and Sons, 1946).

37. Mead, Cyrus D. The Relations of General Intelligence to Certain Mental and Physical Traits, Contributions to Education, No. 76 (New York: Teachers College, Columbia University, 1916).

38. Metheny, Eleanor. Breathing Capacity and Grip Strength of Preschool Children, Studies in Child Welfare, No. 390 (Iowa City: University of Iowa Press, 1940).

39. Mintz, Alexander. "A Study of Indications of Unstable Unilateral Cerebral Dominance, Reading Disability, and Mental Deficiency," Psychological Bulletin, XXX (October 1933), pp. 565-66.

40. Monroe, Marion. "Methods for Diagnosis and Treatment of Cases of Reading Disability Based on the Comparison of the Reading Performance of 120 Normal and 175 Retarded Readers," Genetic Psychology Monographs, IV (October, November, 1928), pp. 335-456.

41. Nielson, J. M. Agnosia, Apraxia, Aphasia (New York: Paul B. Hoeber, Inc., 1947).

42. Oak, Laura Sawyer. Motor Difficulties of Left-Handed Children in Learning to Write and to Draw. Unpublished Doctor's Dissertation, Yale University, New Haven, Connecticut, 1930.

43. Oates, David W. "Left-Handedness in Relation to Speech Defects, Intelligence, and Achievements," Educational Forum, VII (June 1929), pp. 91-105.

44. Orton, Samuel Torrey. "A Physiological Theory of Reading Disability and Stuttering in Children," New England Journal of Medicine, CXCIX (November 1928), pp. 1046-52.

45. _____, Reading, Writing and Speech Problems in Children (New York: W. W. Norton and Co., Inc., 1937).

46. Parson, Beaufort S. Lefthandedness (New York: Macmillan Co., 1924).

47. Peters, Henry N. "The Mirror Tracing Test as a Measure of Social Maladaptation," Journal of Abnormal and Social Psychology, XLI (October 1946), pp. 437-48.

48. Ranschburg, P. Die Lese-und Schreibstorungen des Kindesalters (Halle a. S.: C. Marhold, 1928).

49. Robinson, Helen M. "Treatment of Severe Cases of Reading Disability," Journal of Educational Research, XXXII (March 1939), pp. 531-35.

50. _____. Why Pupils Fail in Reading (Chicago: University of Chicago Press, 1946).

51. Snyder, A. M. and Snyder, Marguerite A. "Eye Preference Tendencies," Journal of Educational Psychology, XIX (September 1928), pp. 431-33.

52. Stauffer, Russell G. Certain Psychological Manifestations of Retarded Readers. Unpublished Doctor's Dissertation, Temple University, Philadelphia, 1947.

53. Stern, W. "Ueber Verlagerte Raumformen," Zeitschrift fur angewandte Psychologie, Leipsic, II (1909), pp. 498-526.

54. Stevens, H. C. and Ducasse, C. J. "The Retina and Right-Handedness," Psychological Review, XIX (1912), pp. 1-31.

55. Teegarden, Loreen. "Tests for Tendency to Reversal in Reading," Journal of Educational Research, XXVII (October 1933), pp. 81-97.

56. Terman, Lewis M. The Hygiene of the School Child (New York: Houghton Mifflin Co., 1914).

57. Twitmyer, E. B. and Nathanson, Y. S. "The Determination of Laterality," Psychological Clinic, XXII (September-November 1933), pp. 141-48.

58. Updegraph, Ruth. "Ocular Dominance in Young Children," Psychological Bulletin, XXIX (November 1932), p. 654.

59. Van Riper, Charles. "An Experimental Investigation of Laterality in Stutterers and Normal Speakers," Journal of Experimental Psychology, XVII (April 1934), pp. 305-13.

60. _____. "The Quantitative Measure of Laterality," Journal of Experimental Psychology, XVIII (June 1935), pp. 372-82.

61. _____. Speech Correction (New York: Prentice Hall, Inc., 1946).

32. Warren, Neil, and Clark, Brant. "A Consideration of the Use of the Term Ocular Dominance," Psychological Bulletin, XXXV (May 1938), pp. 298-304.

63. Weisenburg, Theodore, and McBride, Katherine E. Aphasia (New York: The Commonwealth Fund, 1935).

64. Witty, Paul A. and Kopel, David. "Sinistral and Mixed Manual-Ocular Behavior in Reading Disability," Journal of Educational Psychology, XXVII (February 1936), pp. 119-34.

65. Wolfe, Lillian S. "An Experimental Study of Reversals in Reading," American Journal of Psychology, LII (October 1939), pp. 553-61.

66. _____. "Differential Factors in Specific Reading Disability," Pedagogical Seminary and Journal of Genetic Psychology, LVIII (March 1941), pp. 45-70.

I. Ma

Th
of sch
VIII.
courte
City.
purpo
pils w
Vacat
allowe
to dev
struct
as pos
Ow
compe
tively
a met
possib
Hence
specif
stanc
ities
tentio
would
invest
of ind
the sp

*Depa

SUBSTANCE SYMBOLISM: A STUDY IN LANGUAGE PSYCHOLOGY

GUSTAV KALDEGG*
Highland University
Las Vegas, New Mexico

I. Material and Purpose of Investigation

The present investigation is based on a set of school compositions covering Grades III to VIII. The material was obtained through the courtesy of the Friends Seminary, New York City. The test was arranged for the particular purpose and under uniform conditions: The pupils were asked to write about the subject "My Vacation" with a class period of 50 minutes allowed for the work. They were encouraged to develop their thoughts freely, specific instructions by the teacher being avoided as far as possible.

Owing to the small size of classes the set of compositions as a whole assumed a comparatively limited extent. We had therefore to adopt a method of sampling that utilized the largest possible portion of the total material available. Hence, we consistently disregarded anything specific that might have appeared in the circumstances of life or the psychological particularities of individual pupils, and centered our attention upon obtaining a statistical basis that would be broad enough for the purpose of the investigation. With an adequately large number of individual tests used, the probability was that the specific factors which possibly modified the material would balance themselves from grade to grade. A uniform quota of 2000 words per grade was established. This practically exhausted the aggregate contributions of grades III and IV. These aggregates turned out to be the smallest in the series, resulting from the shortness of the individual essays. Those of the other grades exceeded the quota in varying measures, but it was of course not permissible to use the surplus appearing in each case for some special selection that could not be carried out to the same extent or not at all in classes with less material. Hence, for the sake of consistency, we abstained throughout from examining essays as to any specific qualification. Compositions were taken at random out from each class, and grouped together to the point where the quota was filled. In order to arrive at the round number 2000, the word-count in each grade had to be concluded somewhere in the midst of the essay that had been taken up last. The exact fraction of this complementary copy used in each instance is of no relevance to the total calculation. The following survey, therefore, gives the sum of essays per grade in whole numbers, the partially used composition being included:

STRUCTURE OF MATERIAL

Grade	Total Number of Pupils and Compositions	Boys	Girls	Total Extent of Material	Average Length of Compositions
III	15	4	11	2000 words	133 words
IV	17	6	11	" "	118 "
V	11	3	8	" "	182 "
VI	7	4	3	" "	286 "
VII	10	4	6	" "	200 "
VIII	10	9	1	" "	200 "
Sum	70	30	40	12000 words	Av. 171 words

*Department of Modern Foreign Languages.

While in sum total the girls definitely outnumber the boys (40 to 30), there are wide variations in the distribution of sexes from grade to grade. Under the given circumstances, this distribution could have been made equal only by contracting the statistical material, and such a reductive selection did not seem indicated in any event. Another manner of approach, however, has been used to analyze the share of each sex in the whole developmental picture (cf. Tables VI-VIII). Yet it has turned out, as one could have expected considering the particular nature of the development, that sex difference does not play an essential part.

All investigations on the process of learning one's native tongue may be arranged in two chronological groups: those dealing with the initial phases of the process, and those concerned with its continuation and completion during the scholastic period and based principally on written material. The first category of developmental inquiries has certainly contributed more than any related discipline to throw light upon the fundamental factors in the genesis of language, and has thus proved to be a valuable supplementation to linguistics, properly speaking. The second category can hardly be said to have produced any similar results. It is limited on the whole to the external, quantitative aspect of linguistic progress and accordingly directed toward demonstrating that, for instance, the average length of sentences, the complexity of the sentence structure or the average extent of the vocabulary increases from one age group to another. But it seldom touches upon the inner, qualitative changes such as the transformation of basically concrete ideas by way of metaphorical transference, the advance from lower to higher levels of abstraction and the progressive conceptualization of language. That this very course of development must play a decisive part in the secondary period with which we are dealing, would seem to be a foregone conclusion. It is scarcely known, on the other hand, as to its details.

There is, however, a definite reason why these finer features of the process of linguistic growth usually escape psychological analysis. The difficult point evidently is that traditional grammar offers no criteria adequate to the purpose. For its divisions and categories, based in the main on a logical description of fully developed language, rather correspond to the structural features of the latter than to developmental gradations. There remain only a few fundamental schemes which, by their very generality, also indicate some broad lines of development. Of such sort are the differentiation of sentence and word, the arrangement of the whole vocabulary according to parts of speech and a few other classifications according to verbal types. Elementary distinctions of this kind if properly interpreted in terms of psychology would seem to form the whole grammatical equipment needed to approach the essential things in the initial phases of language acquisition. They are, however, obviously inadequate as a basis for measuring any further linguistic progress. Many investigators have felt indeed this lack of suitable developmental standards, and accordingly have pointed out that it would be desirable to emancipate oneself from the customary categories of grammar and establish special criteria corresponding to facts of language genesis.

There arises, however, the question as to how one may turn aside from the well-prepared roads of grammatical tradition and yet not get lost in indefiniteness. If it is a matter of presenting a new angle of linguistic analysis for theoretical purposes, an explanation of general nature is usually sufficient. It does not seem possible, on the other hand, to define a novel criterium out of itself with such sharpness that the definition could be applied unhesitatingly to any context within given language material and thus would meet the specific requirements of developmental analysis. Assuming then that a principle of language genesis has been found it will still be necessary, in the interest of clear communication, somehow to fit that principle into static grammatical categories of general currency. In each instance, a combination of such categories will have to be used, and it needs must grow more extensive the more completely the principle is to be expressed and covered. But then the danger arises that the definition of the developmental principle may become unduly diffused and intricate. It is evident that this difficulty can be solved only by making such a compromise between the conflicting requirements of completeness and lucidity as will fit the individual case.

The present study is concerned in particular with a certain group of abstract nouns, namely, those referring to measures of time. Its essential objective is to ascertain, within this semantic area, different types of use and context representing different levels of development. Following the above indicated procedure, we shall have to establish first a principle of language genesis on a theoretical basis, and then translate it more or less completely into familiar categories of practical grammar.

II. Abstracts of Time as Individual Words

The semantic group under consideration consists in the main of nouns expressing measures or periods of time, as "hour", "day", "night", "month", "year", "summer", "interval", "vacation", etc. It furthermore comprehends a small number of words denoting position in time or points of time, i.e. such terms as "beginning", "end", and "middle" when they are

associated with time relations in a given context. These types of nouns combining to form a homogeneous semantic group are being treated as abstracts of time.

Among the compound expressions entering into the present analysis there are some that involve one abstract of time each and ouner involving several such terms (cf. e.g. "holiday", "school-day" as against "summer morning"), the constituent parts are spelled solid in some instances and as separate words in others. For the sake of consistency, compounds of any of these kinds have been counted throughout as each one word.

The relative distribution of abstracts of time on the various grade levels of our material is shown in Table I.

The absolute number of time abstracts used varies only little and without any significant relation to the sequence of grade levels. Viewing the number of different words there would seem to be a slightly rising trend toward the end of the scale. The data were further condensed in groups as shown in Table II.

This negative result seems clear enough in its own way, and we can certainly save the trouble of ascertaining the proportion of abstracts of time to the total number of nouns or trying any other statistical variations. We will center our attention rather on the differences in conception and application that lie within the realm of nouns of time. They depend on certain basic features of linguistic symbolism. A discussion of these general conditions will then be the immediate next step to take.

III. Definition of "Substance-Symbolism"

The form of linguistic symbolism under consideration is intimately connected with the peculiar nature and function of abstract nouns. The traditional grammatical division contradistinguishes this class of words from that of substance-names or concrete nouns. The semantic area of the abstract noun includes measures of space and time, qualities, states, actions, in brief, all possible aspects in which substances can be viewed. The term "attributes"—being understood here in a very broad sense—is customarily used to subsume that whole variety of ideas. Grammatical theory further explains that it is the primary and typical function of the noun to denote substances while attributes are primarily expressed by

TABLE I

DISTRIBUTION OF ABSTRACTS OF TIME AS INDIVIDUAL WORDS

Grade	Total Number of Abstracts of Time	Number of Different Words Used	Total Extent of Material
III	73	18	2000 words
IV	72	20	" "
V	64	16	" "
VI	71	20	" "
VII	67	21	" "
VIII	70	21	" "

TABLE II

CONDENSATION OF THE PRECEDING TABLE

Grade	Total Number of Abstracts of Time Used	Number of Different Words Used	Total Extent
III-IV	145	38	4000 words
V-VI	135	36	" "
VII-VIII	137	42	" "

The distribution of the absolute figures is as haphazard as before. The only progressive trend, if it can be called so, lies perhaps in the fact that the top group shows a higher number of different words used than either of the others. All in all, it may be stated that neither the absolute frequency nor the variety of expressions undergoes changes of developmental significance.

other verbal categories.[1]

This broad logical schema, no matter to what extent it may be applicable to individual and particular facts, gives at any rate a clear account, I think, of the fundamental arrangements of words and ideas in language. It follows from it that ideas that can be thought of as attributes centered around substances must find expression especially in those types of words which modify noun-concepts in established syntactical combinations. It is evident that such words, when understood in their proper meanings, can be joined only to substance-names but not to abstracts which themselves indicate attributes under the image and in the grammatical form of substance-concepts. When therefore an abstract noun combines with an adjective, a verb or a preposition, the latter term is found to shift to a metaphorical level, as in "a long speech", "to solve a problem", "on this condition", and the like. Metaphorical transferences of the same character appear in certain combinations between each two attribute nouns (cf., e.g., "the length of the speech" or the "solution of the problem"), and finally in those instances where a substance-name enters into an appropriate relation with an attribute-noun ("the root of the evil", "a bulwark of freedom", etc.).

The metaphorical type that has just been outlined is what we understand by substance-symbolism. It is essentially based on the fact that the various points of view from which concrete things or substances can be looked upon and qualified come to be adopted in analyzing abstract ideas. In the phrases given above, the figurative element becomes manifest at first sight, while in other such instances one may have to trace back lost basic meanings in order to re-establish the original metaphor. It seems obvious at any rate that the development of substance-symbolism must play its definite part also in the linguistic growth of the individual. This development so far as it involves abstracts of time will be examined more closely in the following section.

IV. Two Developmental Types of Abstracts of Time

Verbal combinations that include abstracts of time practically always show an element of substance-symbolism. It is easy to see, for instance, that a transference of spatial relations to time underlies such prepositional phrases as "in the morning", "at night", etc. Time furthermore appears to be provided with the attribute of countability when we speak of something having been done "within three days" or "on the third morning", and we ascribe to it, as it were, physical existence in such statements as "it was morning" or "it is night."

In all these instances, however, the metaphorical element is of such primitive and self-evident nature that we hardly become aware of it. But it assumes a somewhat different form in contexts like "The day passed" or "We spent the day in such and such a place" where time in the first place is likened to a person or thing moving forward, and in the second place conceived under the image of money spent. These similes are certainly of a more specific and more striking character than those in the first group of phrases.

The two forms of substance-symbolism we have indicated will henceforth be referred to as substance-symbolism of low and of high degree respectively, and the abstracts of time involved shall be called by analogy low- and high-degree abstracts. The similes of the first category, associated with the most general attributes of physical things such as existence, countability or spatial extension, present themselves as being indispensable in conceiving and operating, with, the idea of time. They evidently are linguistic images of a universal character. The metaphors of the second kind, on the other hand, show variations even within the area of European languages. Compare, e.g. the following translations of the word "spend" as in "spend time": French passer, i.e. properly "to go beyond", as in the adapted English phrase; Latin agere having the basic sense "to drive" (sc. cattle); Greek among other expressions tribein, properly "to rub", "wear out"; Czech travati, properly "to digest" (food). Substance-symbolism of low and of high degree can then be considered in principle as two different types, one representing a more ancient, the other a more recent stage in the development of thinking and language.

It will be necessary now to elaborate this broad and general distinction into greater accuracy and, according to the procedure described at the outset, to establish a definition whereby the theoretical principle of distinction will somehow be expressed in current terms of practical grammar. The list of examples that follow is to serve as a guide for our further discussion. It is so arranged as to illustrate in two opposed groups the main types of contexts in which abstracts of time occur. The individual sentences follow as colosely as possible original passages of our material.

The series of examples A and B may be contrasted in several manners. The points of comparison are: the metaphorical force which the abstract of time develops within its proper verbal group, its logical role within each con-

1. Cf. Henry Sweet, A New English Grammar, Logical and Historical (Oxford, England, 1892), Part II, par. 28 ff., pars. 150, 165 ff.

A	B
1. I went out early in the morning (on that day, at night, etc.)	1. The day came (passed, was nearing a close, etc.)
2. After two weeks in the country we returned home.	2. When the two weeks were up we returned home.
3. By the time we had gone there it started raining.	3. The summer was not like riding.
4. One day (every day, twice a month, a few days later, etc.) a concert was organized.	4. We spent the day in the country, (spent it working, horseback-riding, etc.)
5. We could play tennis only seventeen days.	5. We had only seventeen days of tennis.
6. We saw a six weeks old puppy.	6. They celebrated her birthday.
7. It was morning (evening, Monday, etc.) when we left.	7. She was looking forward to the holiday.
8. This was my first day in Pinetown.	8. We had great profit from our spare time.
9. After a two hours' trip we took a good rest.	
10. This was the event of the day.	
11. We met there our friends of last year.	

textual whole, and its specific function within the external sentence structure.

As we go over the individual sentences we find the noun of time to be governed now by a preposition (A 1-3), then by another noun (A 9-11), then again by an adjective (A 6), or to be in a direct relation with the verb of the sentence (A 4, 5, 7, 8, B 1-8); furthermore it is modified by numerals, pronominal adjectives and similar expressions in most instances. Each of these verbal groups involves a more or less pronounced element of substance-symbolism. In the pertinent combinations of series A the underlying metaphor is of general and colorless nature, often barely perceivable, answering thus the description of substance-symbolism of low degree. The analogous combinations of series B are based on comparisons of time to a moving body or person (1, 2), to material possession (4, 5, 8) or on its quasi-identification with what is thought of as falling under a given period of time (3, 6, 7). These various kinds of specific similes would seem to come under the head of substance-symbolism of high degree.

The suggested arrangement according to two degrees of metaphorical force continues being a merely relative and approximative one. This grouping, however, which in itself does not admit of any precise formulation happens to run largely parallel with other, sharper distinctions within the particular domain of time-abstracts.

As we compare the sentences in the two series with regard to each contextual whole we see ourselves confronted with two fundamentally different uses of abstracts of time. In the statements of the first series the critical noun retains throughout its basic logical function, namely, to denote a measure of time as applied to external events or states, it being irrelevant whether these in their turn find expression in the verb of the sentence, in a nomen actionis (9, 10), an adjective (6) or perhaps an added dependent clause (7) or are not specifically expressed at all but only indicated elliptically (understand "the first day of my stay" or similar in 8, "our friends whom we had made last year" in 11). In the sentences of series B, on the other hand, periods of time are said to come, to pass, to be had, etc., are, in one word, presented like being themselves agents or goals of actions or centers of states, and thus the noun of time comes to convey something beyond a logically subordinate idea of measure. The grouping in question viewed from this particular angle assumes the shape of a definite dichotomy so that we may contra-distinguish

time-abstracts of low and of high degree in brief as follows: the former retain the basic logical function peculiar to nouns of this semantic area, while the latter appear in a secondary logical function.[2]

The contrast between uses A and B which so far we have tried to clarify on theoretical grounds can be reduced in the end to something purely external and expressible in terms of practical grammar. This criterion lies in the varying syntactical role of the noun of time. Within the sentences of series A the noun of time performs one or the other of the following functions:

It combines with a preposition to an adverbial modifier of time (1-3). It is in the accusative of time (4, 5, 6). It forms the logical subject of a sentence in which the grammatical subject is expressed by the impersonal pronoun (7); it plays the part of predicate noun (8). It is constructed as a genitive dependent on another noun (9-11).

In the sentences of series B it is used in turn as grammatical subject (1-3), direct object (4-6) and prepositional object (7-8).[3]

Thus the two types of time-concepts coincide in the main with two definite groups of syntactical constructions. This points out a direct way toward establishing a practical rule of distinction. We will henceforth regard as high degree abstracts such nouns of time as perform in the sentence one of the three functions mentioned under B. There is, on the other hand, no more need for our remembering specially the many functions characterizing the low-degree abstracts of series A. Any nouns of time that do not fall under the definition of high-degree abstracts can be assigned automatically to the opposed category.

There remains to be mentioned only certain contextual possibilities that are not specifically included in the sample sentences. Our definition of high-degree abstracts in terms of syntactical function is naturally meant to be independent of the particular character which the verbal expression may assume in a given sentence. It holds good, that is to say, irrespective of whether the verb connected with the noun of time has finite form as it does in our sample sentences or, possibly, appears as verbum infinitum ("We wanted to spend the day....", "spending the day", etc.), whether this verb be predicate of a main or a subordinate clause in the individual instance. The definition also admits of direct application to phrases combining several nouns of time as, for instance, "the beginning of the vacation" or "the last day of the month". The governing expression of each such group will have to be counted as high-degree abstract when it plays one of the critical three parts within the sentence-whole ("The last day of the month came", "We spent the last day in N.", "She was looking forward to the last day of the month"), while the dependent genitival expression at any rate falls outside the category under discussion.

The case is somewhat different when it comes to combinations in which the noun of time is governed by a quantifier as e.g., in "a part of the day" or "a number of days." Verbal groups of this special kind must evidently be treated each as one unit if they are properly to be arranged in terms of our syntactical criterion. When therefore any such group taken as a whole performs one of the critical functions within the sentence ("A number of days had passed", "We spent a number of days in N.", etc.) the noun of time it contains will have to be included in the category of high-degree abstracts. Thus we have finally arrived at the point where the entire discussion on this category can be boiled down to a brief rule of thumb:

A given noun of time is to be reckoned among high degree abstracts:

1. When it appears as
   a. Grammatical Subject
   b. Direct Object
   c. Prepositional Object

   within the sentence.

2. When it is used as a partitive genitive dependent on a quantifier, and if this group as a whole performs one of the three syntactical functions specified above.

Table III shows the distribution, as ascertained in our material, of high-degree abstracts.

---

2. What we take to be the basic logical function coincides with the basic meaning in most of the terms concerned although, on the other hand, the two may be entirely different from each other (cf. for instance, the word "end"). The semantic structure of the individual word does not, however, affect the above dichotomy since any term used as abstract of time in a given context becomes assignable on this very ground to either of the logical types defined.

3. Although adverbial modifiers and prepositional objects interlap in certain cases their delimitation is very definite where modifiers of time are involved. Syntactical elements of the latter category always answer questions that include the idea of time ("when?" "since when?" etc.), and this evidently does not apply to nouns of time in the role of prepositional objects. An analogous difference in function separates the accusative of time ("how long?" "how old?") from what is equal to it in form, namely, the direct object. In our syntactical terminology we follow George O. Curme, A Grammar of the English Language (New York, Boston, 1931).

The number of low-degree abstracts, which can be found by simply deducting in each instance the figures of the second column from those of the first, has no further significance for the developmental analysis.

Assuming that high-degree abstracts of time, taken as a special type, tend to gain ground within the developmental period considered, their increasing use has evidently to be measured somehow in proportion to other expressions that refer to time. But the very numbers of their occurrences seem to reflect this rising trend, according to the above tabulation (middle column). This is, I think, accounted for by the accidental fact that the total number of time-abstracts used remains about the same throughout the various grade levels of our material. Hence, the greater or lower frequency of high-degree abstracts cannot be considered either as intrinsically symptomatic, and in expressing the developmental trend which we presume to inhere in this particular type it seems necessary as a matter of principle, to use a relative standard of measurement. Such a standard is obtained by establishing the proportion on each grade level between the total number of nouns of time and the number of those that fall under the category discussed. [4]

The relative frequency of high-degree abstracts can be seen from the last column: it increases regularly from the 3rd to the 7th grade level, with only a slight regression from the 7th to the 8th.

As we arrange our data in two-year groups the developmental picture assumes the shape as seen in Table IV.

The relative frequency of high-degree abstracts shows a considerable increase from one group to the other, and the total progress amounts to nearly three times.

TABLE III

DISTRIBUTION OF HIGH-DEGREE ABSTRACTS OF TIME

Grade	Total Number of Abstracts of Time	Number of High-Degree Abstracts of Time	Relation in Percents
III	73	6	8
IV	72	9	13
V	64	11	17
VI	71	14	20
VII	67	20	30
VIII	70	19	27

TABLE IV

CONDENSATION OF THE PRECEDING TABLE

Grade	Total Number of Abstracts of Time	Number of High-Degree Abstracts of Time	Relation in Percents
III-IV	145	15	10
V-VI	135	25	19
VII-VIII	137	39	28

It should be remembered at this point that the grammatical thumb-rule which we have set up for the contextual type under discussion has come about by way of a compromise. The syntactical characteristics which, within the domain of time-concepts, coincide with substance-symbolism of high degree have been utilized to translate more or less exactly a general developmental principle into current categories of grammar. The aptness of this methodical procedure as well as the underlying principle itself are now to be tested further. For this purpose we shall vary the thumb-rule in such a manner as to have it agree still more closely with the theoretical principle.

The above definition is based exclusively on

4. The correctness of this manner of claculation will be evidenced more directly in another connection (cf. p. 26c ff).

the position which the noun of time occupies in a given sentence-whole. But the distinction between substance-symbolism of low degree and that of high degree may also appear in the attributive terms modifying the noun of time. Compare the following examples:

A	B
1. We stayed there two (a few, many, etc.) days; we stayed there the whole day.	1. We started out on a sunny (rainy, cool) morning.
2. It was on the same (first, next, etc.) day.	2. It was a pleasant (exciting) day.
3. At that time they used to wear this type of costume.	3. In the old time (in past times) they used to wear this type of costume.

The words that function as attributive modifiers within series A denote basic characteristics of physico-spatial order such as number, quantity and sequence, while those of series B refer to specific qualities and states, and thus constitute as it were adjectives in the proper sense of the term.

According to this difference in semantic character of the attributive modifiers, the element of substance-symbolism too assumes different forms. The metaphors involved in the combinations between the time-abstracts and adjectival expressions of the first series evidently come under substance-symbolism of low degree. In the combinations of the second series, we find definite periods of time to be identified with the associated events and experiences (B 1-2), time to be compared with an organism subject to change and a body in motion (B 3, phrases outside and inside the parenthesis respectively). We are then dealing here with metaphors of exactly the same type as in those contexts where the expression of time performs one of the critical three functions within the sentence, and in instances of both kinds this expression is so used as to pass beyond its basic role of denoting a logically subordinate idea of measure. Accordingly, nouns of time modified by adjectives such as those in series B are to be considered an additional group of high-degree abstracts.

There again a traditional arrangement of practical grammar presents itself as a basis for a more exact definition. I am referring to the division into descriptive and limiting adjectives which in Curmes's Grammar of the English Language is thus explained:

> ".....A descriptive adjective expresses either the kind or condition or state of the living being or lifeless thing spoken of: a good boy, a bright dog, a tall tree, a sick boy, a lame dog. The participles of verbs are all descriptive adjectives, since they indicate either an active or passive state: running water, a dying soldier, a broken chair.
>
> A limiting adjective, without expressing any idea of kind or condition, limits the application of the idea expressed by the noun to one or more individuals of the class, or to one or more parts of the whole, i. e. points out persons or things: ....this book ....my house, each house, many books.... etc." (Vol. II, Sec. 8, p. 42)
>
> The following sections (8-10, p. 43 sq.) present the usual groupings within the class of limiting adjectives: possessive adjectives, demonstrative, numeral, indefinite adjectives (some, many, a few, other, all, every, etc.), what, which as interrogative or exclamatory adjectives, and a few minor groups which are of no relevance for our purpose.
>
> All other adjectival terms fall under the class of descriptive adjectives which does not admit of any further sub-division."

Thus the indicated adjectival types A and B basically agree with limiting and descriptive adjectives respectively. The latter classification being adopted, the additional group of high-degree abstracts we are considering can be readily delimited, and the definition presented below will then cover the entire category.

A given noun of time is to be reckoned among high-degree abstracts:

1. When it appears as
   a. Grammatical Subject
   b. Direct Object
   c. Prepositional Object

   within the sentence.

2. When it is used as partitive genitive dependent on a quantifier, and if this group as a whole performs one of the three syntactical functions specified above.

3. When it has a descriptive adjective as attributive modifier.

The relative distribution of high-degree abstracts according to this three-point rule is shown in Table V.

The sub-divisions of the second column before the last refer respectively to: the occurrences, which have already been listed in an earlier place, of high-degree abstracts according to sections 1 and 2 of the rule, the cases counted in addition on the basis of section 3, the total number of occurrences according to the expanded definition.

High-degree abstracts of time in terms of the two-point rule occasionally are connected also with descriptive adjectives as, for instance, in "A new day dawned" or "We spent that beautiful day in N." It naturally follows that the additional group is confined to those instances in which the descriptive adjective modifying a noun of time constitutes the exclusive criterion for arranging that noun under the category in question: "It was a beautiful day", "I went out on a sunny morning", etc. Accordingly, the occurrences under section 3 are only few. They are not, however, without having some effect on the statistical picture as a whole: The only irregularity that appeared with the application of the two-point definition, namely, the regress in the 8th grade is eliminated under the expanded rule, and the relative distribution of high-degree abstracts shows now a continued progressive trend. With 12% on the third and 36% on the eighth grade level, the total increase amounts to more than two and a half.

Thus the regularity of the developmental curve increases as the rule of thumb is brought into closer agreement with the theoretical principle. From a practical angle, however, the two-point rule certainly seems preferable since it merely presumes the identification of some elementary syntactic constructions, and yet expresses with sufficient distinctness the developmental trend investigated. [5]

The tabulations that follow show the developmental data arranged according to the sex of the pupils. For the purpose of this analysis, we have separated the whole sampling into compositions by boys and compositions by girls. As we look over the preliminary survey relative to the structure of the material, we realize that the aggregate of each sex group per class is too small in most instances to afford a foundation for statistical comparison. In this part of the investigation, therefore, two-year periods have been used throughout as a basis. (See Table VI).

As we combine the final results of Tables VI and VII, we arrive at the following summary in Table VIII.

In some groups, the average score of the boys is slightly above that of the girls, in others slightly below or at the same level. The total average, however, would indicate a not negligible difference in favor of the boys. But this is based merely on the accident of numbers. It so happens that the essays of the boys are comparatively more numerous in the higher strata of the material as those of the girls are in the lower strata. No conclusive variations are then to be noted in connection with sex difference, and as far as this investigation goes, one must assume that the development considered takes an equal course with both sexes.

The data in Tables VI-VIII also deserve attention from another point of view. They clearly bear out, I think, the correctness of the relative measure that has been applied to that development in all instances. With the aggregate contributions of both sexes unseparated, the sum of all abstracts of time has proved about equal from grade to grade. As a result, the number of high-degree abstracts rises toward the upper grade levels, and this very increase seems to express the developmental trend. But it is the relation in each case between the two values which alone affords a reliable standard under varying contingencies. This in particular becomes evident, I suppose, from the analysis of the material by sexes. In the boys' compositions, the sum of abstracts of time markedly increases from one two-year period to the other, while it decreases correspondingly in those of the girls. It is the peculiar structure of the material, again, which accounts for this opposition. As it can be easily figured from the preliminary survey, the aggregates of the boys grow larger from age-group to age-group and those of the girls become smaller. (Multiply the sums of essays per age-group and sex, with the approximative average length for each two-year period.) The result of that distribution is that on the part of the boys, the number of high-degree abstracts increases excessively from period to period (compare the corresponding values in Table IV), while on the part of the girls it changes but very slightly throughout the series. This abrupt contrast which evidently cannot reflect developmental facts gives place to a plausible parallelism as we regard the relation in each case of the two numbers. We arrive then at the above shown developmental line which runs about equally for the equivalent age-groups of both sexes, and this certainly brings into sharper view the peculiar psychological significance of that relation.

---

5. In case someone should wish to repeat, by means of material of his own, the experiment that has been presented, let us specially note that it is not all necessary for this purpose to go into the painstaking business of a word-count. If we have sorted out an equal number of 2000 words per grade, we have done only in order to gain the required basis for the negative demonstrations in Tables I and II. But any such calculation becomes superfluous in ascertaining the significant relations in terms of Tables III-V or VI-VIII.

TABLE V

DISTRIBUTION OF HIGH-DEGREE ABSTRACTS OF TIME IN TERMS OF THE EXPANDED DEFINITION

Grade	Total Number of Abstracts of Time	Number of High-Degree Abstracts			Relation in Percents
		Secs. 1, 2	Secs. 3	Total	
III	73	6	2	8	11
IV	72	9	2	11	15
V	64	11	1	12	19
VI	71	14	2	16	23
VII	67	20	3	23	34
VIII	70	19	6	25	36

TABLE VI

HIGH-DEGREE ABSTRACTS OF TIME IN TERMS OF THE TWO-POINT DEFINITION AS THEY ARE DISTRIBUTED OVER THE COMPOSITIONS OF BOYS AND GIRLS

	Grade	Sum of all Abtracts of Time	Number of High-Degree Abstracts of Time	Relation in Percents
BOYS	III-IV	37	4	11
	V-VI	53	11	21
	VII-VIII	88	25	28
	Total	178	40	Total Average 22
GIRLS	III-IV	108	11	10
	V-VI	82	14	17
	VII-VIII	49	14	29
	Total	239	39	Total Average 16

TABLE VII

HIGH-DEGREE ABSTRACTS OF TIME IN TERMS OF THE THREE-POINT DEFINITION AS DISTRIBUTED OVER THE COMPOSITIONS OF BOYS AND GIRLS

	Grade	Sum of all Abtracts of Time	Number of High-Degree Abstracts of Time	Relation in Percents
BOYS	III-IV	37	5	13
	V-VI	53	12	23
	VII-VIII	88	30	34
	Total	178	47	Total Average 26
GIRLS	III-IV	108	14	13
	V-VI	82	16	20
	VII-VIII	49	18	37
	Total	239	48	Total Average 20

TABLE VIII

COMBINED FINAL RESULTS OF THE TWO PRECEDING TABLES

	Relative Frequency of High-Degree Abstracts of Time			
	According to Table VI		According to Table VII	
Grade	Boys	Girls	Boys	Girls
III-IV	11%	10%	13%	13%
V-VI	21%	17%	23%	20%
VII-VIII	28%	29%	34%	37%
Total Average	22%	16%	26%	20%

V. Conclusions

At the outset we have already indicated that an external, quantitative and an internal, qualitative aspect of linguistic growth may be distinguished, with accordingly two opposed categories of criteria for linguistic maturity. This opposition takes on a precise form when viewed from the particular angle of progressing word knowledge. That the vocabulary range regularly increases with mental age is a well known fact that underlies various specific methods of intelligence-testing. They are concerned fundamentally with the number of words mastered or the quantitative aspect of word knowledge, and therefore can take into account but one definite meaning or approximative semantic cross-section of the individual term. There is, on the other hand, the manner of using words or the qualitative aspect. It forms the basis for the standard of development which we have employed in the analysis of our material, and any of the many criteria that could conceivably be established according to types of use and context would fall under the same category.

The interrelation and the contrast between the two aspects of word knowledge becomes clear, I think, from the particular case investigated in the foregoing pages. Let us glance over the various sentences that have been cited above in illustrating high-degree abstracts of time. The verbal groups involving this type of time-concepts largely consist of words that prove to be quite current and elementary as to their basic uses. The phrase "to have a good time" may serve as an example. If a quantitative word test were made among children of the range of mental ages under consideration, this could only result in showing that the terms "have", "good" and "time" as used in "have an apple", "a good boy" and "what time is it?" respectively, are definitely familiar even to the youngest of the group. The particular combination, however, which is formed by the same three words embodies a time-abstract of high degree according to section 1b of our rule and thus represents a conceptual type that develops intensely throughout the whole range of mental ages. This qualitative progress in the manner of using words and the quantitative increase in vocabulary range involve then two standards of linguistic maturity which, in principle, may be considered as mutually independent. The contrast between the two manners of measurement stands out all the more sharply when we look upon it in the light of the fact that abstracts of time taken as individual words or quantitatively fail to show any progressive trend at all within the critical period.

It remains to be examined, however, whether the process of learning a language actually takes in several directions so that different linguistic criteria could bring out different features of an individual's mental set-up. There are at any rate, facts of common experience indicating that that process is of a complex rather than simple-linear character. Thus it can be seen from daily teaching experience that the faculty of acquiring a language involves a number of more specific abilities. Any such component factor as, e.g., auditory comprehension might show, with a given individual, a conspicuously strong or weak development in proportion to the other factors. As regards the two aspects of language command with which we are dealing in the present connection, they manifest themselves as psychological realities on a higher level of achievement quite particularly. Thus among leading writers, we find some using an overwhelmingly large vocabulary as against others who obviously utilize the semantic potentialities of the individual term still more intensely than the former do, since with a less extensive stock of words, they yet attain the same degree of clarity and adequacy. The quantitative aspect appears then at its maximum in the first instance, while the qualitative one proves to be relatively stronger in the second. It can be reasonably assumed that already with growing linguistic maturity, those two opposite aspects are more or less sharply differentiated, and closer investigations might result in showing that an even development of quantitative and qualitative word knowledge and the special prevalence of either factor give each some definite indication as to an individual's psychological disposition.

A foremost source of new developmental criteria presents itself in the genesis of linguistic symbolism. Basically concrete ideas are being transferred into the mental realm and undergoing metaphorical sublimation in a continuous process that permeates the history of language as well as individual linguistic development and conspicuously denotes the progress of thinking. It is evident that this evolution also must imply some element of regularity so that definite metaphorical types correspond to definite genetic phases. When it comes to treating these things systematically the individual development is likely to offer leads that are hard to find in the multitude of historical details and accidents. Psychological investigations which, on the basis of adequate criteria, trace the growth in linguistic ability with the school child should then be expected to throw additional light also on certain problems of linguistics. The preceding study has been limited to analyzing that development from one specific angle. It will, however, have fulfilled its purpose if it has given some illustration of the wide possibilities that are still open.

EFFECT OF THE ORGANIZATION OF LEARNING EXPERIENCES UPON THE ORGANIZATION OF LEARNING OUTCOMES: II. STUDY OF THE PROBLEM BY MEANS OF FACTOR ANALYSIS

EDWARD J. FURST
University of Michigan
Ann Arbor, Michigan

INTRODUCTION

This is the second of two articles dealing with the relationship between a particular pattern of learning experiences and the organization of selected outcomes of general education. The first article presented fairly detailed information on the background and procedure of the investigation (2). Some of this information is high-lighted below.

Coefficients of intercorrelation among twenty-seven achievement measures and two aptitude measures were obtained on two groups of students for performance at the beginning of the eleventh grade and again at the end of the twelfth. It had been possible to match the two groups on scholastic aptitude, but not on initial achievement or on initial pattern of test intercorrelations. One group of 63 students had pursued a program of studies in a conventional high school curriculum, while another group of 60 students had completed the first two years of the four-year College program at the University of Chicago.

Methods appropriate to the respective programs of general education were utilized to obtain information on the nature of the learning experiences afforded students. Independent judgments were made of the extent to which particular courses or combinations thereof had contributed to intellectual growth toward each of the objectives measured. Three degrees of emphasis were established, corresponding to the inferred extent of preparation for accomplishing the test exercises on each objective: "marked," "some," and "little." The two programs were then compared with reference to these relative degrees of emphasis and to certain other broad features such as instructional materials and evaluation procedures.

Analysis of data was confined in the first article to a study of changes in coefficients of correlation for three groupings of tests: subject field, mental process, and relative degree of emphasis of objective. The hypothesis that emphasized objectives will tend to become interrelated as outcomes of learning were supported only by restricted aspects of the data. There was good evidence that learning in both groups had become compartmentalized along subject-matter lines.

A more economical approach to the study of such interrelationships is provided by the method of factor analysis. Through the use of this method it is possible to describe the statistical organization of these various abilities, skills, and knowledges as it existed before and after the two years of education covered. It is then possible to note whether or not differentiated learning experiences during such a period of instruction were manifested in changes in the pattern of organization itself. This article will deal with the factor analysis of the basic data.

STUDY OF THE PROBLEM BY MEANS OF FACTOR ANALYSIS

Hypotheses tested

Two hypotheses will be tested in this part of the study. The first of these is the following:

Hypothesis I. The general factor will make a relatively greater contribution to the total variance in the final factor patterns for both the College and high school groups than in the initial factor patterns, but the total contribution in the final pattern will be greater for the College group than for the high school group.

The justification for this hypothesis has already been given in the previous article. There it was pointed out that the respective courses of study seemed to differ greatly in the extent to which they provided opportunities for the development of interrelationship among various outcomes.

In the case of the College program, on the one hand, the conditions for fostering interrelationship were twofold. First, the marked emphasis of most of the objectives at least provided for correlation of objectives within courses in the same subject field. Secondly, many

of these objectives were common to several of the subject fields, so that there was considerable opportunity for related skills to be concurrently developed in the several fields. Typical of such skills, of course, are the interpretation of data in various forms, the application of principles in new situations, reading and analysis of original documents, and the evaluation of evidence for hypotheses or propositions.

In the case of the high school program, on the other hand, the conditions for fostering interrelationship were much more restrictive. Explicit emphasis was not given to many of the skills and abilities in the social studies, natural sciences, and mathematics. Not only was there little emphasis of such objectives within the subject fields but also there was little evidence of concerted effort to emphasize similar objectives throughout several subject fields. The organization of the curriculum into relatively discrete courses seemed to suggest further that the presentation of student learning experiences in subject-matter compartments would itself lead to the compartmentalization of learning. With compartmentalization, of course, learning outcomes are not likely to be greatly interrelated between different subject fields.

In short, the nature of the learning experiences in the College program seemed to point in the direction of a considerable increase in interrelationship among the various outcomes appraised, while those in the high school program seemed to point to only a small increase in interrelationships.

The second hypothesis test is the following:

Hypothesis II. The group factors in the final factor pattern for both the College and the high school groups will differ from those in the initial pattern in the direction of greater scope, and they will differ in their composition in the respective final patterns.

It is suggested here that two kinds of group factors would emerge from a factor analysis of the final test intercorrelations for the College group: (1) content factors paralleling the several subject fields, and (2) "functional" factors paralleling those major outcomes which cut across subject-field boundaries and appear to be relatively homogeneous with respect to the thought process most involved. The first set of factors would thus include a Language Arts factor, a Humanities factor, a Social Sciences factor, a Physical Sciences factor, and a Mathematics factor; the second set, a verbal comprehension factor, an induction or interpretation of data factor, a deduction or logical reasoning factor, and a quantitative thinking factor. Further, each of the subject-field factors would include all of the variables or tests within the subject field, with the exception of those tests of non-emphasized objectives in the biological sciences. The existence of two sets of factors in addition to the general factor would mean that many of the tests in the battery would be multi-factor, that is, of complexity greater than two.

It is also suggested that only one set of factors would emerge from a factor analysis of the final test intercorrelations for the high school group: an English or Language Arts factor, a Social Studies factor, a Physical Sciences factor, and a Mathematics-Quantitative factor. These are substantially subject-field factors and, in view of the compartmentalization of instruction and learning in the high school program, their emergence would be surprising. It was not expected that all of the tests within a field would cluster together; most of the tests of non-emphasized objectives would be expected to have a very high specificity and to have very little in common with the remaining tests either in the same subject field or in different subject fields. In other words, the scope of such content factors would be restricted largely to the tests of objectives which had received at least "some" emphasis in instruction.

General comments on the method of analysis

The bi-factor method as outlined by Holzinger was used in the present factor analysis (3:111-154). According to the bi-factor plan a theoretical frame of reference is set up in which a general factor is assumed to run through all n variables, specific factors in each of the n variables, and in addition certain group factors, each including at least two of the n variables. A given variable may occur in more than one of the groups; such an occurrence is known as an "overlap."

The data of the present study lent themselves quite well to analysis by the bi-factor method. For one thing, the tables of intercorrelations were generally positive throughout; the few negative correlations that did occur were not significantly different from zero and could be treated as due to chance fluctuations. Although there were indications of "overlapping" group factors (3:102), the correlation analysis suggested the possibility of subject-field factors but not of "functional" factors cutting across the several fields. Thus it seemed that few of the tests would have a complexity greater than two and that therefore the analyses would be simplified and economical of time and effort.

Since reliabilities had not been determined for each of the tests in the four situations, the uniqueness, or that portion of the total test variance which is not attributable to communality, was not divided into specificity and unreliability. It was not felt essential for purposes of the study to spend time and labor to get such information. The main concern here was with the communality, or the contributions of the com-

mon factors to the total test variance, inasmuch as the study dealt in large part with interrelationships among the various tests of educational objectives.

Each of the pattern plans finally retained represents an attempt to get a best fit to the data. It is possible that minor changes in grouping, account of slight overlaps, and the recognition of additional "doublets" would have produced slightly better fits to the observed correlations than did the patterns finally chosen. In any case, adequacy of fit was indicated by conventional tests of completeness of factorization.

The general factor and communality in each situation

The first hypothesis was tested in two ways: (1) by noting changes in the contributions of the general, group, and unique factors to the total test variance from initial to final testing; and (2) by studying the relationship between the relative degree of emphasis of various objectives and changes in the communality of their corresponding tests from initial to final situation.

It can be noted from Table I that the proportions of the general, group, and unique factors were quite similar on both testings of the College group. The slight increase in communality did not seem to support the stated hypothesis inasmuch as most of the measured objectives had been given considerable emphasis in the program of courses.

In the high school group, on the other hand, the proportions of these factors showed some shifts from initial to final testing. Communality increased, the increase being divided fairly evenly between the general and group factors. Since this increase was expected, the data are in agreement with the hypothesis.

A more crucial question, of course, is whether there would be a hierarchy of changes in communality varying directly with the degree of emphasis of the measured objective—"little," "some," and "marked." The appropriate data for the College group did not permit a decisive test of the hypothesis because twenty of the twenty-seven educational objectives appraised had received a "marked" degree of emphasis, only three, "some," and only four, "little" emphasis. No clear trend was evident in the changes in communality for tests of "marked" objectives, nine of the tests showing an increase and eleven a decrease in communality. There was a similar lack of association between degree of emphasis and change in communality for the other two categories of emphasis.

Parallel data for the high school group do not bear out well the hypothesis. Thus, three of five tests of objectives receiving a "marked" emphasis showed an increase in communality, but six out of nine tests of objectives receiving "some" emphasis showed an increase and seven out of eight tests of objectives receiving "little" emphasis showed an increase.[1]

Before proceeding with the second hypothesis, it may be well to consider the nature of the general factor in each situation. A tentative answer may be obtained by reviewing the general factor coefficients. Since within either group these coefficients were similar from initial to final situation, only the final coeffic-

TABLE I

PERCENTAGE CONTRIBUTIONS OF GENERAL, GROUP, AND UNIQUE FACTORS TO TOTAL TEST VARIANCE

	College Group		High School Group	
Factor	Initial	Final	Initial	Final
General	31.9	32.6	25.5	30.2
Group	20.6	19.3	13.6	19.9
Unique	47.5	48.1	60.9	49.9
Total	100.	100.	100.	100.

1. Tests 15, 18, 19, 5 and 6 were omitted from consideration here. The first three were not included in the factor analysis of initial intercorrelations, while the last two were not included in the factor analysis of final intercorrelations. Each of these tests had extremely low relationships with other achievement tests in the battery.

ients will be reviewed.

Turning first to the final pattern of the College group, one may note the tests with the highest coefficients:

Understanding of the meaning of words (1)	.790
Reading and analysis—social issues (8)	.753
Reading and analysis—natural sciences (21)	.731
Knowledge of structure and language of mathematics (24)	.713
Judging relations—contemporary society (14)	.705
L-score, A. C. E. Psychological Examination (29)	.704

Tests 11, 16, and 26 also had high coefficients.[2] Hence measures of reading and verbal abilities were prominent. The presence of a mathematics test in this group need not conflict with the interpretation of this factor as a verbal factor; the test involved mathematical concepts and symbolism. Further insights into the nature of this factor may be gained by noting some of the tests with the lowest loadings:

Knowledge about painting and architecture (6)	.332
Q-score, A. C. E. Psychological Examination (28)	.363
Analyzing sentences in grammatical terms (2)	.379
Detecting errors in sentence structure (4)	.416
Application of knowledge—social sciences (15)	.444
Judging validity of evidence—physical sciences (19)	.463

It seems, therefore, that the general factor in this situation was strongly saturated with reading and verbal abilities, although it was not simply scholastic aptitude. There was a rather close similarity of this factor to that in the initial situation.

The general factor in the final high school pattern, in contrast to the foregoing, reflected important aspects related to school achievement. This is seen clearly in the group of tests having the highest coefficients:

Reading and analysis—natural sciences (21)	.741
Judging relations—American history (13)	.721
Knowledge of facts in the biological sciences (22)	.685
Judging validity of evidence—social issues (16)	.657
Relating knowledge of American history to social issues (9)	.655
Summarization of trends—contempo temporary society (12)	.646
Summarization of trends—American history (11)	.638
Graphical interpretation—physical phenomena (27)	.629
Knowledge of structure and language of mathematics (24)	.618
Knowledge of facts in American history (10)	.607

Many social science tests appear in the above list, as do several measures of knowledge in different subject fields. Conspicuously absent are measures of scholastic aptitude. The latter appear in the following group of tests with low general-factor coefficients:

L-score, A. C. E. Psychological Examination (29)	.280
Q-score, A. C. E. Psychological Examination (28)	.301
Application of knowledge—social sciences (15)	.320
Analyzing sentences in grammatical terms (2)	.377
Knowledge of facts about the physical sciences (17)	.395

In view of the prominence of this factor in various aspects of academic achievement, it seems to be in the nature of a general achievement or studiousness factor. Although there were many shifts in this pattern from initial to final testing, the general factor in either situation seemed to be primarily a reflection of those influences associated with specific aspects of achievement in school subjects rather than with scholastic aptitude as such.

The group factors in each situation

The second hypothesis was tested by comparing the group factors in the initial and final patterns.

(1) Verbal or language factors. It is apparent from the data in Table II that the composition of the verbal or language factor in each sample did not change materially from initial to final testing. With one exception in each situation, the cluster of variables is the same.

For the College group, the coefficients in the initial and final situations did not differ greatly in magnitude, and the contribution of the clusters to the percentage of total test variance was also similar. According to the emphasis of language objectives in the College pro-

2. Summarization of trends - American history, Judging validity of evidence - social issues, Understanding of the fundamentals of verbal logic, respectively.

TABLE II

COEFFICIENTS OF VERBAL OR LANGUAGE FACTOR FOR EACH GROUP ON INITIAL AND FINAL TESTS*

Test	Test No.	Initial		Final	
		College Group	High School Group	College Group	High School Group
		Verbal Comprehension	Language Arts	Verbal Comprehension	Language Arts
Understanding of the meaning of words	1	259	512[b]	400	588
Analyzing sentences in grammatical terms	2	...	237	...	637
Organizing notes into logical order	3	...	241	...	318
Detecting errors in sentence structure	4	...	394	569	648
Analysis of poetry	7	571	...	...	444
Reading and analysis—social issues	8	247	247	122[c]	567[c]
Judging validity of evidence—social issues	16	351[a]	269	247[c]	442[c]
L-score, A. C. E. Psychological Examination	29	321	322[b]	433	496
Percent of total variance due to this factor		2.34	3.00	2.66	8.26

*In this table and in subsequent tables the decimal point for coefficients has been omitted.

[a]Overlap with Contemporary Affairs factor

[b]Overlap with Verbal-Humanities factor

[c]Overlap with Social Sciences factor

TABLE III

COEFFICIENTS OF SOCIAL SCIENCES FACTORS(S) FOR EACH GROUP ON INITIAL AND FINAL TESTS

Test	Test No.	Initial		Final	
		College Group	High School Group	College Group	High School Group
		Contemporary Affairs; American History[a]	**	Social Sciences	Social Sciences
Reading and analysis—social issues	8	...	...	265[b]	634[b]
Relating knowledge of American history to social issues	9	286	...	593	401
Knowledge of facts in American history	10	744	...	505	321
Summarization of trends—American history	11	227	...	238	326
Summarization of trends—contemporary society	12	365	...	377	242
Judging relations—American history	13	233	...	290	394
Judging relations—contemporary society	14	692	...	382	250
Application of knowledge—social sciences	15	...	...	...	...
Judging validity of evidence—social issues	16	255[b]	...	257[b]	303[b]
Percent of total variance due to this factor		4.89	...	4.04	4.23

**A social sciences factor did not emerge in this situation.

[a]The two social science factors named are here treated as one. Factor II, Contemporary Affairs, includes tests 12, 13, 14, and 16. Factor III, American History, includes tests 9, 10, and 11.

[b]These tests showed an overlap with Factor I: Verbal Comprehension or Language Arts, as the case may be.

TABLE IV

COEFFICIENTS OF SCIENCE FACTORS FOR EACH GROUP ON INITIAL AND FINAL TESTS

Test	Test No.	Initial		Final	
		College Group	High School Group	College Group	High School Group
		Natural Sciences	Physical Sciences-Mathematics	Natural Sciences	Physical Sciences-Mathematics
Knowledge of facts about the physical sciences	17	497	437	675	610
Application of principles—physical sciences	18	685	...	580	468
Judging validity of evidence—physical sciences	19	617	...	472	...
Interpretation of data—physical sciences	20	477*	330	475	228
Reading and analysis—natural sciences	21	281	505	363	367
Knowledge of facts in the biological sciences	22	...	...	317	...
Application of facts—biological sciences	23	367	...	...	...
Knowledge of structure and language of mathematics	24	...	485	...	695
Ability to make elementary mathematical manipulations	25	...	675	...	611
Understanding of verbal logic	26	...	...	...	...
Graphical interpretation—physical phenomena	27	...	487	443*	411
Q-score, A. C. E. Psychological Examination	28	...	363	...	460
Percent of total variance due to this factor		5.30	6.21	5.75	7.46

*This test overlaps with a separate Mathematics-Quantitative Thinking factor.

gram, and by hypothesis, one would have expected this factor to broaden and include the other language objectives as well. Instead, three objectives did not cluster with this group nor with any other group factor in the final results; their test variance was largely accounted for by specificity. Because of the absence of several of the English tests from the cluster and because of the predominance of several tests emphasizing verbal relations, understanding of word meaning, and skills in reading comprehension, this factor was named "Verbal Comprehension."

For the high school group, the coefficients of these tests with the language factor all showed an increase in magnitude from the initial to the final situation, and the percentage contribution to the total test variance increased accordingly. This increase in interrelation occurred despite the fact that only one of the corresponding objectives had been given a "marked" degree of emphasis in the program, namely, vocabulary. The nature of the tests in this cluster and their coefficients suggested that the underlying factor was not simply one of verbal comprehension; other language skills played an important part. Hence this factor was named "Language Arts." It stands in contrast to the more restricted "Verbal Comprehension" factor which emerged in the College group.

In summary, hypothesis II seemed to be borne out by the results for the high school group, in which a broad, well-defined language arts factor emerged as expected. This hypothesis, however, was not supported by the results for the College group, in which a narrow and relatively unimportant verbal comprehension factor persisted with little change from the initial testing. No explanation is forthcoming for the failure of a broader and more pronounced language factor to emerge in this latter group. Indeed, the emphasis upon language skills in the whole College curriculum would seem to have favored the development of interrelation among them.

(2) Social sciences factors. Table III shows the coefficients for these factors.

Although two separate social science factors emerged in the initial pattern of the College group, one such factor appeared in the final pattern. In neither situation, however, did the cluster of tests make a particularly large contribution to the total test variance. In view of the emphasis given to these objectives in the related courses, one would have expected the corresponding tests to make a much greater contribution to variance than they actually did.

A factor very similar to that of the College group emerged in the high school group in the final situation. As with the former group, the coefficients of most of the variables in the cluster were low and hence their combined contribution to the total test variance was also low. In any case, the emergence of this factor was apparently the result of instruction toward several of the social science objectives during the preceding academic year.

In summary, hypothesis II seemed to be borne out by the results for the high school group in that a social science factor emerged. This factor was not an important one, however, in terms of its over-all contributions to total test variance. This hypothesis was not supported by the results for the College group, in which much the same factors appear in the initial and final situations. Moreover, the composition of the factor and its loadings were similar to those in the high school group on the final tests, although the pattern of emphases in the social sciences courses of the respective programs were quite different.

(3) Science factors. Table IV shows the coefficients for these factors.

It is evident from the data in the table that the composition of the respective science factors did not change much from the initial to final situation. Generally the same variables present in the initial cluster were also present in the final cluster. Whereas a factor named "Natural Sciences" emerged in both situations for the College group, one named "Physical Sciences-Mathematics" emerged in both situations for the high school group.

Hence a more restricted factor appeared in the College group, although one would have expected a "Physical Sciences-Mathematics" factor to emerge just as it did in the high school results, inasmuch as the related objectives had generally received a "marked" degree of emphasis in the College program. What happened, as will be shown, is that a separate "Mathematics-Quantitative Thinking" factor appeared.

(4) Mathematics factors. Table V shows the coefficients of mathematics factors. It is to be noted that the data for the "Physical Sciences-Mathematics" factor of the high school group have been repeated here because a separate mathematics-quantitative thinking factor did not emerge in this group.

This factor reflected the emphases of the various mathematics objectives in the College program, for tests of verbal logic (26) and graphical interpretation (27) now appear in the final cluster along with tests of other mathematics objectives.

Emphases appear to be similarly reflected in the high school group. Thus, tests of objectives which had received only "little" or "some" emphasis either did not appear in the final cluster or, if they did, had coefficients of lesser magnitude than tests of objectives which had received "marked" emphasis.

In short, this second hypothesis was not well borne out by the data on the College group. It was expected that two sets of group factors

TABLE V

COEFFICIENTS OF MATHEMATICS FACTOR FOR EACH GROUP ON INITIAL AND FINAL TESTS

Test	Test No.	Initial		Final	
		College Group	High School Group	College Group	High School Group
		Mathematics-Quantitative	Physical[a] Sciences-Mathematics	Mathematics-Quantitative	Physical[a] Sciences-Mathematics
Knowledge of facts about the physical sciences	17	...	437	...	610
Application of principles—physical sciences	18	...	...	...	468
Judging validity of evidence—physical sciences	19	...	...	...	...
Interpretation of data—physical sciences	20	408[b]	330	...	228
Reading and analysis—natural sciences	21	...	505	...	367
Knowledge of structure and language of mathematics	24	476	485	443	695
Ability to make elementary mathematical manipulations	25	782	675	777	611
Understanding of verbal logic	26	...	...	425	...
Graphical interpretation—physical phenomena	27	...	487	397	411
Q-score, A. C. E. Psychological Examination	28	558	363	368	460
Percent of total variance due to this factor		4.54	6.21	4.39	7.46

[a]Repeated from Table IV. A separate mathematics-quantitative factor did not emerge in this situation.

[b]Overlaps with the Natural Sciences factor in this situation.

would emerge: one set based upon community of content and another upon community of mental process. Instead, a single set of factors emerged largely compartmentalized by subject field. The composition of these factors, moreover, was rather stable over the two-year period covered. This hypothesis, however, seemed to be fairly well borne out by the data on the high school group. It was expected that well-defined subject-field factors would emerge, and they did. These factors tended to be more inclusive than was expected, however.

Implications for education

A major implication of these findings is that students in both groups tended to organize their learning on a subject-matter basis in much the same form of organization as that in which the learning experiences were presented to them. There was little evidence of a tendency to do equally well in similar types of exercises in different subject fields. Such consistency from field to field was not indicated by the data. A student's success in the achievement of an objective in one field had little relationship with his achievement of a similar objective in another field.

Various influences which may operate to limit the extent of organization have already been noted in the first article, but two of these will be mentioned again. The very specialization of content or subject matter operates as a limiting condition upon the development of interrelation. The student has to have a certain mastery of content to be able to carry on complex thinking with that content. The student also constitutes a set of limiting conditions. A particular pattern of aptitudes, interests, and study methods contributes to a certain degree of unevenness of development in any one individual. This unevenness of development seems to occur even though the individual has grown considerably in all of the desired directions. It accounts in part for the lack of complete consistency of performance from one outcome to another.

Practically, these findings suggest that deliberate steps must be taken to provide for organization of learning if such is desired as an important outcome of education. If higher interrelationship between outcomes in different subject fields is desired, learning experiences in different fields must be selected, organized, and presented in such a way as to take advantage of the similarities of subject matter and course objectives.

SUMMARY

This is the second of two articles dealing with the relationship between a particular pattern of curricular experiences and the organization of selected outcomes of general education.

Coefficients of intercorrelation among twenty-seven achievement tests and two aptitude tests were obtained early in the eleventh grade and again at the close of the twelfth on two groups of students. One group had pursued a program of studies in a conventional high school curriculum, while the other had completed the first two years of the four-year College program at the University of Chicago.

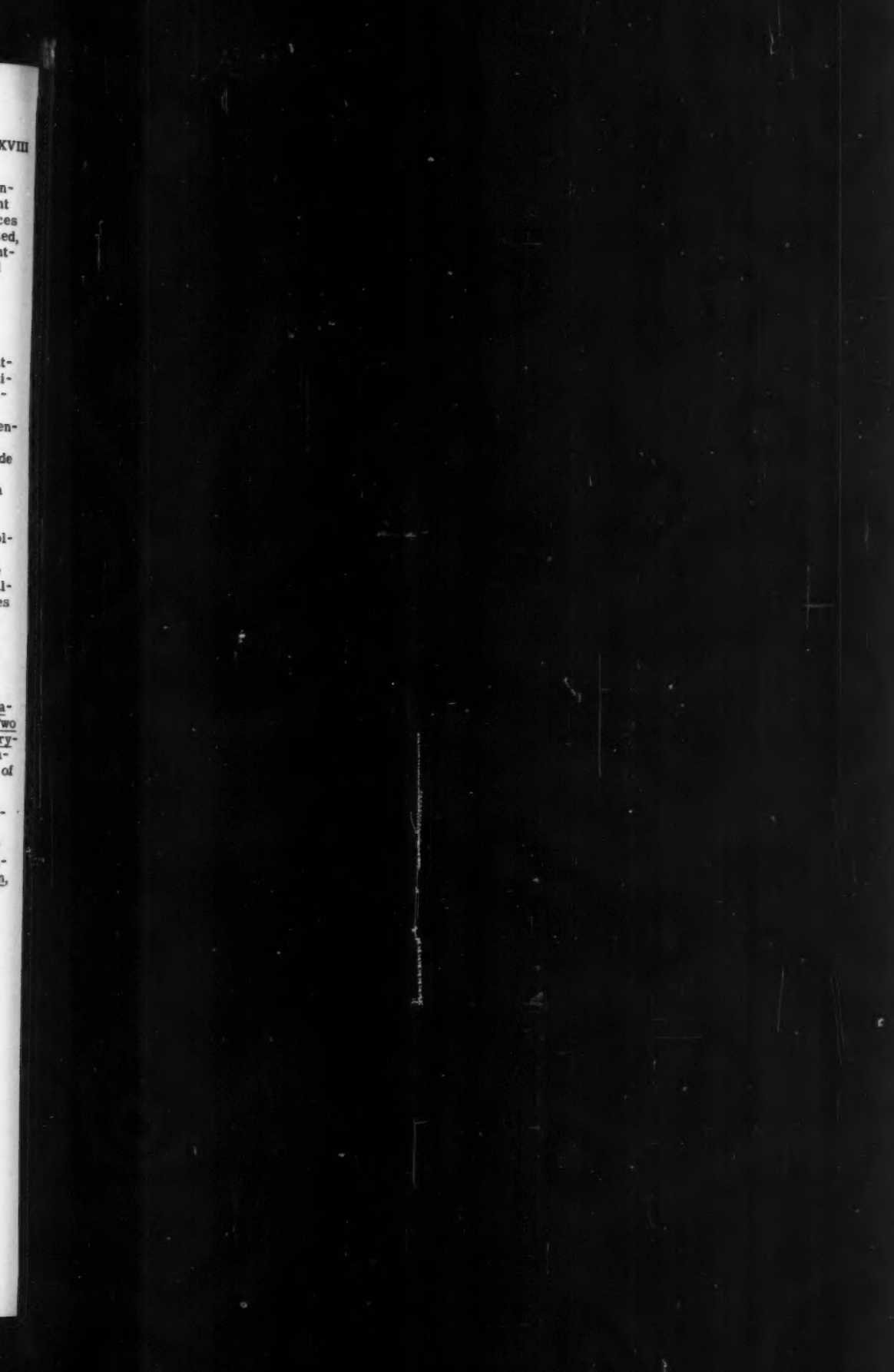
The correlation matrices representing the four possible situations of the study were analyzed by the bi-factor method. Two hypotheses were tested. The findings and their implications for education were discussed.

REFERENCES

1. Furst, Edward J. Changes in the Organization of Various Abilities and Skills After Two Years of General Education at the Secondary-School Level. Unpublished Ph. D. Dissertation, Department of Education, University of Chicago, 1948. Pp. viii+249.

2. Furst, Edward J. "Effect of the Organization of Learning Experiences upon the Organization of Learning Outcomes. I. Study of the Problem by Means of Correlation Analysis," Journal of Experimental Education, XVIII (March 1950), pp. 215-228.

3. Holzinger, Karl J., and Harman, Harry H. Factor Analysis (Chicago: University of Chicago Press, 1941), pp. xii+417.



A New

TEACHER PERSONNEL RESEARCH

MONOGRAPH NO. 3

by
DAVID G. RYANS
LAWRENCE P. BLUM
KENNETH R. DOANE
LOIS G. NEMEC

This new monograph (132 pages) contains four reports in which answers are sought to such questions as:

- **How well do teachers perform on the National Teachers Examination?**
- **How do persons preparing to teach compare with those of other selected professions?**
- **What is current practice in the education of teachers in the United States?**
- **How is teacher education related to teacher certification?**

Ready Now ***Price $2.50***

Dembar Publications, Inc.

114 South Carroll Street **Madison 3, Wisconsin**

Specifications for Manuscripts

. . . for the . . .

JOURNAL OF EDUCATIONAL RESEARCH

. . . and the . . .

JOURNAL OF EXPERIMENTAL EDUCATION

1. All manuscripts must be typewritten, double spaced, and on one side of the sheet only. Mimeographed and ditto sheets are acceptable only when very clearly printed.

2. All unusual symbols or formulae must be very clearly typed or hand printed in black ink. To avoid costly printers' composition charges it may be necessary for us to make cuts of difficult matter, or to print your material by the photo-offset lithography method. The latter means photographing your actual copy. It is expensive to have material redrawn by our own artists, and retracing or duplicating increases the hazards of error. See that your copy is correct and complete as you wish to have it reproduced. The men who work on your manuscripts are not trained to understand the working symbols and language of your technical field.

3. The same restrictions and requirements as in Paragraph 2 apply to all drawings, graphs or other illustrated materials,—they must be neatly done, in black ink, on bond paper or tracing cloth suitable for reproduction. Remember our magazines are printed in black ink only. Color graphs should be changed by the author to provide different kinds of shading for the different areas. For example: diagonal lines for red, vertical lines for blue, etc. Provide a key.

4. All tables, graphs, etc., on sheets by themselves must be properly labeled and identified in relation to the written copy of the manuscript.

5. Footnotes must be complete as to author, title, place of publication, publisher, date and pages. They must be numbered consecutively throughout the article.

6. Bibliographical notes must be complete and arranged alphabetically.

The cooperation of all prospective authors in following these rules is earnestly required. It is difficult to produce technical journals accurately, neatly, and on time under the best conditions. Promptness in printing, economy, and accuracy will be promoted by carefully prepared manuscripts.